

**This Page Is Inserted by IFW Operations  
and is not a part of the Official Record**

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning documents *will not* correct images,  
please do not report the images to the  
Image Problem Mailbox.**

## (12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
12 July 2001 (12.07.2001)

PCT

(10) International Publication Number  
**WO 01/50405 A1**

(51) International Patent Classification<sup>7</sup>: **G06F 19/00**

(74) Agent: **FRANZ, Paul, E.; Bose McKinney & Evans LLP, 2700 First Indiana Plaza, 135 North Pennsylvania Avenue, Indianapolis, IN 46204 (US).**

(21) International Application Number: **PCT/US01/00208**

(22) International Filing Date: 4 January 2001 (04.01.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

09/478,251	6 January 2000 (06.01.2000)	US
09/724,115	28 November 2000 (28.11.2000)	US

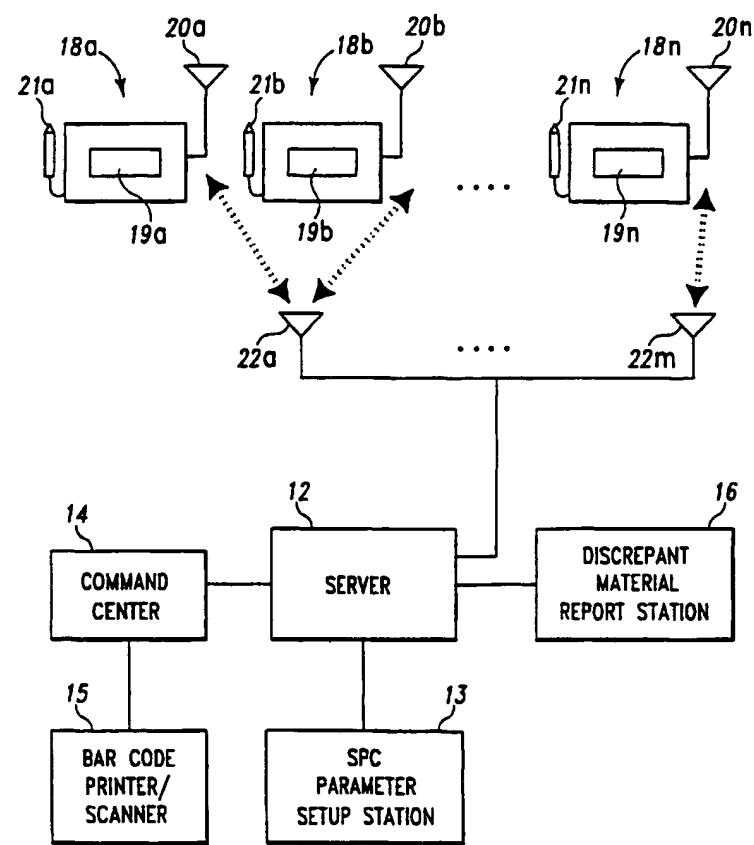
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

(71) Applicant and  
(72) Inventor: **RAPP, Roy, W., III [US/US]; 2494 Leonard Road, Martinsville, IN 46151 (US).**

[Continued on next page]

(54) Title: A PAPERLESS TABLET AUTOMATION APPARATUS AND METHOD



(57) Abstract: A factory floor tablet automation system (10) enables the storing, collecting and processing manufacturing data generated at a facility during manufacturing. A server (12) is located at each facility, and a plurality of portable tablet devices (18) are located in each facility. One or more transceivers (22) are located throughout each facility, each transceiver (22) being connected to the server (12) in each facility. The plurality of portable tablet devices (18) is in wireless communication with the server (12) through the transceivers (22) and the tablet antennas (20).

**WO 01/50405 A1**



**Published:**

- *With international search report.*
- *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## A PAPERLESS TABLET AUTOMATION APPARATUS AND METHOD

### TECHNICAL FIELD OF THE INVENTION

The present invention is related to apparatus and methods for factory automation and tracking. In particular, the present invention is directed to a factory automation apparatus which includes a plurality of portable tablets and an automation server in wireless communication, and the software for implementing a paperless factory automation system with that apparatus.

### 10 BACKGROUND OF THE INVENTION

Facilities which machine custom parts are traditionally managed with a variety of paper systems. For example, time records are kept on time cards which need to be gathered and analyzed. Component drawings for a given job are created on large sheets of paper and provide the necessary dimensional and manufacturing requirements for the job. Other examples include manufacturing orders, manufacturing instructions, statistical process control (SPC) data sheets and yellow tag or discrepant component data sheets. Each of these paper systems require manpower to gather and analyze the data and physical space to store and archive the various papers.

20 Additionally, the nature of the paper system is susceptible to lost information, incorrect information, and information recorded in disparate documents which are not readily available to the person needing the information. Papers can be misplaced or information transcribed incorrectly. Paper systems also significantly delay responses to customer inquiries because the manager must determine who is working on the job, either seek out that person or check a job board for status and sometimes determine additional information, such as why a job is suspended. The potential also exists that the information located on the job board is not current.

25

Therefore, a need exists for a system that can move beyond the traditional paper management systems and allow employees to enter all types of data into an easily accessible system that collects, processes and stores the data in a central location which is also easily accessible from various locations within or remote from the facility. The system needs to collect and compile employee data, such as time

records, location and current assignments; and job information, such as schedules, current status and supporting documentation. The system also needs to enable managers the capability to instantly view the employee and job information so that the manager can respond to customer inquiries and can quickly reallocate resources to  
5 meet scheduling requirements.

#### SUMMARY OF THE INVENTION

The present invention is directed to an apparatus and method for a paperless factory automation system. The apparatus of the paperless factory automation system  
10 includes a plurality of portable tablets used by operators, a central automation server in wireless communication with the tablets. The method collects, processes and stores information for a plurality of jobs being performed by a plurality of operators in a facility.

The factory floor tablet automation system collects, stores and processes  
15 manufacturing data generated throughout a facility during manufacturing, and makes the manufacturing data accessible from various locations throughout the facility. The factory floor tablet automation system includes a server computer, multiple portable tablet devices, and one or more transceivers. The server computer has a processor unit and storage device, and maintains a plurality of databases including a job  
20 assignment database, an operator assignment database, a job description database, a drawing repository, a process control database, and a time keeping database. Each of the multiple portable tablet devices has a processor unit, a memory device, a display screen, an input/output device and a tablet antenna. The transceivers are located throughout the facility and each transceiver is connected to the server computer. The  
25 plurality of portable tablet devices is in wireless communication with the server computer through the transceivers and the tablet antennas. A job is assigned to an operator in the facility and one of the portable tablet devices is allocated to the operator. The operator accesses and receives information from the server computer and the storage device through the allocated portable tablet device. The server  
30 computer receives, stores and processes information from the operator through the allocated portable tablet device for tracking the status of the job and for tracking time allocation of the operator.

The factory floor tablet automation system can also include a command center which has a processor unit, a display device, and an input device. The command center communicates with the server computer, and is used to populate and retrieve data from the databases stored on the central server, and to determine job status and operator time allocation. A bar code printer and a bar code reader can be connected to the command center. The bar code reader communicates with the server computer, and the command center prints a job bar code for each job using the bar code printer. The operator acknowledges receipt of the job by scanning the job bar code with the bar code reader and inputting an operator identifier. The server computer associates the job with the operator that scanned the job bar code.

The factory floor tablet automation system can also include a discrepant material report station having a processor unit, a display device, and an input device. The discrepant material report station communicates with the server computer. Discrepant material reports that identify discrepant materials or parts discovered during processing of a discrepant job are sent to the discrepant material report station. The discrepant material report station tracks proposed dispositions of the discrepant material identified in each of the discrepant material reports, and tracks the approval of the proposed dispositions. The discrepant material report station can present the user with a list of proposed dispositions for the discrepant material including a rework disposition. When the rework disposition is selected, the discrepant material report station enables the user to view scheduled operations, to add operations, to delete operations, to resequence operations, and to associate sketches or resources with operations for further processing of the discrepant material.

The factory floor tablet automation system can also include a statistical process control (SPC) parameter setup station having a processor unit, a display device, and an input device. The SPC station communicates with the server computer. The SPC station enables a user to add an SPC data entry point by positioning an SPC icon for the SPC data entry point on a sketch associated with a job and associating a quality characteristic of the job with the SPC data entry point. A portable tablet device displays the SPC icon for the SPC data entry point when the sketch is displayed on the portable tablet device. The operator can enter SPC data for the quality characteristic of the SPC job by selecting the SPC icon of the SPC data

entry point on the portable tablet device.

A method for factory floor automation which includes collecting, processing, storing and accessing information for a plurality of jobs being performed by a plurality of operators in a facility. Job information is stored for the plurality of jobs on a

5 central computer having a processor unit and a storage device. One of a plurality of portable computing devices is allocated to one of the operators. Each of the portable computing devices includes a processor unit, a memory device, a display device, an input/output device and an antenna, and each of the portable computing devices communicates wirelessly with the central computer. At least one of the jobs is

10 assigned to an assigned operator. An assigned portable computing device is associated with the assigned job by knowing the operator assigned to the job and the portable computing device allocated to the assigned operator. The job information for the job is made accessible to the assigned operator through the assigned computing device. Manufacturing information for each of the jobs is collected, stored and

15 processed on the central computer. The manufacturing information for the jobs is entered by the assigned operator on the assigned computing device. The time allocation of each of the operators to one or more phases of each of the jobs is tracked. The time allocation for each job by an operator is based upon entries made by the operator on their allocated computing device.

20 The method can include allotting jobs to each operator and then querying the operator through the allocated portable computing device as to whether they accept or reject the allotted job. Then assigning the job to the operator only if they indicate that they accept the allocated job.

25 The method can include providing the assigned operator, on their assigned computing device, with a selection of available work centers for performing the assigned job. When the operator selects a work center on the assigned computing device, that work center is allocated to the operator for performing the assigned job.

30 The method can also include collecting first piece inspection data which is part of the manufacturing information. The assigned operator is queried, through their assigned portable computing device, as to whether a first piece inspection is to be performed on the assigned job. When the operator indicates on the assigned computing device that a first piece inspection is to be performed on the assigned job,

the method does not permit the assigned operator to indicate completion of the assigned job until first piece inspection data is entered for the assigned job.

The method can include displaying a job information window on the assigned computing device which shows job information for one of the assigned jobs. The job

5 information window can include a job scroll bar having a job selection button for each of the assigned jobs, enabling the assigned operator to select the assigned job for which job information is shown in the job information window by selecting the job selection button for the assigned job. The job information in the job information window can include time allocation information.

10 The method can also provide access to a plurality of sketches stored as manufacturing information, and each of the sketches is associated with one or more jobs. The job information window can include a view sketch button that enables the assigned operator to select a sketch associated with the selected job, and to display the selected sketch on their assigned computing device.

15 The method can also collect statistical process control (SPC) data and provide a plurality of SPC data entry points for entering SPC data. Each of the SPC data entry points is associated with at least one sketch. An available SPC data entry point is displayed on the assigned computing device when the assigned operator selects a sketch and the available SPC data entry point is associated with the selected sketch.

20 Entry of the SPC data can be made through the assigned computing device by selecting the SPC data entry point. The assigned operator is not permitted to indicate completion of the selected job until all the SPC data is entered for the selected job.

The method can also include a simulated break button in the job information window which allows time tracking to be suspended for the operator and jobs

25 assigned to the operator. This could be used for a break or at lunch. When a portable computing device is allocated to an operator, the portable computing device accepts identification information from the operator to identify the operator. The method then determines whether the operator has suspended tracking of time allocation. If the operator has suspended tracking of time allocation, time tracking is resumed for all of

30 the assigned jobs.

The method can also include a stop job button displayed in the job information window which enables the assigned operator to indicate end of assignment of the

selected job. When the assigned operator selects the stop job button, the operator, using the assigned computing device, indicates whether the selected job is complete or incomplete. When the assigned operator indicates that the selected job is complete, the method checks that all necessary manufacturing information has been entered for 5 the selected job and does not permit complete status for the selected job unless all necessary manufacturing information has been entered. When the job is determined to be complete, the job is flagged as complete, and the job is removed from the assigned jobs of the operator. When the assigned operator indicates that the assigned job is incomplete, the method collects and stores manufacturing information through the 10 assigned computing device related to the status of the job.

A factory floor tablet automation system for storing, collecting and processing manufacturing data generated at a facility during manufacturing, and for making manufacturing data accessible from the facility, can also include a local processor at the facility, and a plurality of portable tablet devices, each of the plurality of portable 15 tablet devices having a processor unit, a memory device, a display screen, an input/output device and a tablet antenna. One or more transceivers are located throughout the facility, each transceiver being connected to the local processor in the facility, and the plurality of portable tablet devices are in wireless communication with the local processor through the transceivers and the tablet antennas. A server 20 computer having a processor unit and storage device, the storage device maintaining a plurality of databases is connected to local processors through a network.

Another method of collecting, processing, storing and accessing information for a plurality of jobs being performed by a plurality of operators in one or more facilities connected through a network includes the steps of storing job information for 25 the plurality of jobs on a central computer having a processor unit and a storage device, and wirelessly linking a plurality of portable computing devices to a local processor in each facility. Each of the local processors in each facility is linked to the central computer, and one of a plurality of portable computing devices is allocated to one of the plurality of operators. An assigned computing device of the plurality of 30 portable computing devices is associated with the at least one of the plurality of jobs, and the job information for the at least one of the plurality of jobs is accessible by the assigned operator through the assigned computing device. Manufacturing information

for each of the plurality of jobs is collected, stored, and processed on the central computer.

Additional objects, advantages and novel features of the invention are set forth in the description that follows, and will become apparent to those skilled in the art  
5 upon reviewing the drawings in connection with the following description.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows an overview schematic of the main components of a paperless tablet system;

10 Fig. 2 shows an overview diagram of the main processes of a tablet automation application for implementing the paperless tablet system;

Figs. 3a and 3b show a functional representation of a tablet login process;

Fig. 4 shows an example of a user login screen;

Fig. 5 shows an example of a welcome screen;

15 Fig. 6 shows a functional representation of a job initiation process;

Fig. 7 shows an example of an assigned operations screen;

Fig. 8 shows an example of the assigned operations screen with a first piece inspection query pop up window;

20 Fig. 9 shows an example of the assigned operations screen with a select work center pop up window;

Figs. 10a, 10b and 10c show a functional representation of a job interface process;

Fig. 11 shows an example of a main job window;

Fig. 12 shows an example of an X-bar chart window;

25 Fig. 13 shows a functional representation of a job setup process;

Fig. 14 shows a functional representation of a job production process;

Fig. 15 shows a functional representation of a first piece inspection verification process;

Fig. 16 shows an example of a first piece inspection verification window;

30 Fig. 17 shows a functional representation of a view sketch process;

Fig. 18 shows an example of a sketch window displaying a sketch with SPC hotspots;

-8-

Fig. 19 shows an example of a sketch window displaying a sketch without SPC hotspots;

Fig. 20 shows a functional representation of an SPC data entry process;

Fig. 21 shows an example of a sketch with a selected SPC hotspot for  
5 measurement entry;

Figs. 22a and 22b show a functional representation of a stop job process;

Fig. 23 shows an example of a stop job window;

Fig. 24 shows a functional representation of a yellow tag process;

Fig. 25 shows an example of a yellow tag window;

10 Fig. 26 shows an example of an e-mail window;

Fig. 27 shows a functional representation of an excess time process;

Fig. 28 shows an example of an excess time code selection window;

Fig. 29 shows a top-level functional representation of a DMR processing application;

15 Fig. 30 shows an example of a DMR selection window;

Fig. 31 shows an example of a DMR view window;

Fig. 32 shows an example of a DMR disposition window;

Fig. 33 shows an example of a rework operations window;

Fig. 34 shows an example of a copy operations window;

20 Fig. 35 shows an example of an operation sketches window;

Fig. 36 shows an example of an add sketch window;

Fig. 37 shows an example of an operation resources window;

Fig. 38 shows an example of an add resource window;

25 Fig. 39 shows a top-level functional representation of an SPC hotspot application;

Fig. 40 shows an example of an SPC sketch selection window;

Fig. 41 shows an example of an SPC sketch window;

Fig. 42 shows an example of the SPC sketch window with a quality characteristics pop up window;

30 Fig. 43 shows an overview schematic of the main components of a paperless tablet system including internet access;

Fig. 44 shows an alert screen generated by an engineering alert; and

-9-

Fig. 45 shows an overview schematic of the main components of a paperless tablet system including a workstation.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

5 A block diagram of a factory floor tablet automation system 10 is shown in Fig. 1. The tablet automation system 10 includes a server computer 12, a command center 14, a plurality of portable tablet computer units 18a-18n, and a plurality of transceivers 22a-22m which are part of a Radio Frequency Local Area Network (RF LAN). Each tablet unit 18a-18n includes an antenna 20a-20n. The server 12 is  
10 connected to the transceivers 22a-22m which are distributed throughout the factory. The tablet units 18a-18n communicate with the server 12 through transceivers 22a-22m.

A tablet unit 18 includes a central processor, memory, a display screen 19 and an operator input device, such as a stylus 21 as shown in Fig. 1. It has been found that  
15 a VADEM PC Companion Model C-100 with RF antenna and stylus peripherals works well in this application.

The command center 14 is used to create identifiers for operators and manufacturing orders and to assign operators to tasks. Fig. 1 shows a bar code printer/ scanner 15 connected to the command center 14. The bar code printer/  
20 scanner 15 can print bar codes which are used to identify operators and to identify orders as they pass through the manufacturing process. When an order is assigned to an operator, the bar code of the order is scanned and the bar code of the operator is scanned to enable the tracking of location, status and progress for the order by the tablet automation system 10.

25 The tablet automation system 10 can also include a discrepant material report (DMR) station 16 to create, process and track the disposition of discrepant material reports (DMRs). When an operator, supervisor or engineer finds a discrepancy in a part, e.g. measurement outside of tolerance, a DMR is written. Inspectors and/or engineers inspect the part and determine the cause of the discrepancy and the proper  
30 disposition of the part, e.g. rework or scrap. The DMR station 16 is used to process the DMR and to track to recommended disposition of the parts associated with the DMR.

-10-

The tablet automation system 10 can also include a Statistical Process Control (SPC) Parameter Setup Station 13 to pre-process sketches in order to add SPC hotspots to sketches used in the tablet automation system 10. The sketch of an item to be produced, or a portion thereof, is loaded from a drawing repository 26 for the user 5 to mark SPC hotspots. The SPC hotspots have tolerances which must be verified by the operator during manufacture of the item. The user of the SPC Parameter Setup Station 13 creates an association between each SPC hot-spot on the sketch and a characteristic of the item being manufactured.

The tablet automation system 10 is controlled by a tablet automation software 10 application 24 represented in Fig. 2. The tablet automation application 24 includes of a tablet login process 34, a job initiation process 35, a job interface process 36, a job setup process 37, a time tracking process 38, a job production process 39, a first piece inspection process 40, a view sketch process 41, an SPC data entry process 42, an excess time process 43, an SPC data viewing process 44, a stop job process 46, a 15 yellow tag process 50 and an e-mail process 51. The processes of the tablet automation application 24 interact to track factory floor operations and to supply necessary data to operators through the tablet units 18. The data created and used by the tablet automation application 24 is stored in a plurality of databases which include an electronic drawing repository 26, a tasks description database 27 containing 20 production steps for manufacturing orders, an SPC measurement database 28, a parts list database 29, a time keeping database 30 and an e-mail bulletin board 32. The management of the databases can be accomplished by different systems, such as a time keeping system for the time keeping database 30, and/or by database software, such as Oracle Manufacturing.

25 In one embodiment, the tablet application 24 is installed on server 12 via a removable mass storage device and is accessed by each tablet unit 18 over the RF LAN 22. This enables software maintenance and updates for the automation system 10 to be performed at one location. Alternatively, the tablet application 24 can be installed on each individual tablet 18. The server 12 functions as the network server 30 for the factory automation system 10 and manages additional factory automation tools which interface with the factory automation system 10. Server 12 includes access to the databases used by the tablet application 24. Data is communicated between the

tablets 18 and the server 12 through the tablet antennas 20 and the plurality of transceivers 22.

The creation of a manufacturing order for the production of a finished product includes several steps. One or more task descriptions are created and stored in the 5 task descriptions database 27 which includes the production steps that are to be carried out in completing the final product. A parts list is created, stored in the parts list database 29, and associated with each task description, which identifies the parts that the operator should need in performing the task description. Any necessary sketches are scanned or otherwise entered into the drawing repository 26. The SPC 10 parameter setup station 13 is used to associate any SPC hotspots in the production process with the appropriate operations sketches. The command center 14 is used to create order identifiers which are associated with production pouches which an operator will use in the manufacture of the finished product or an intermediate product manufactured in the process of making the finished product.

15 At the beginning of a shift, an operator is provided with a tablet 18. If the tablet 18 is not turned on, the operator turns on the tablet 18 and waits for a connection to be established between the tablet 18 and the server 12, and for the tablet application 24 to start the tablet login process 34.

The tablet login process 34, represented in Figs. 3a and 3b, verifies a correct 20 user login and associates a particular tablet 18 with the operator identified by the verified login information. At step 52, the tablet login process 34 displays a login screen 58 on the tablet 18. An example of the login screen 58 is shown in Fig. 4. The login screen 58 includes a keypad 59, a clock number field 61, a PIN number field 63 and a simulated login button 65. The operator, using the keypad 59 and/or the tablet 25 stylus 21, enters his assigned clock number in the clock number field 61 and his selected personal identification number (PIN) in the PIN number field 63. After the operator has entered his login information, he selects the login button 65. In an alternative embodiment, the tablet 18 is equipped with a bar code reader and the operator's company identification badge includes a bar code containing identifying 30 information. In this alternative embodiment, the operator enters his login information by scanning the bar code on his company identification badge and then selects the login button 65.

-12-

When the operator selects the login button 65, the tablet login process 34 verifies the login information at step 54. If the login information is incorrect, control is returned to step 52 and the login screen 58 is redisplayed. If the login information is correct, the tablet login process 34 proceeds to step 53.

5 At step 53, the tablet login process 34 checks to determine whether the previous time that the operator logged off the tablet application 24 they used the Lunch or Break button 127 on the job window 106 which is shown in Fig. 11 (this window and button is discussed later). If the operator last logged off the tablet application 24 using the Lunch or Break button 127, then control is transferred to step  
10 55 at which all time keeping for the operator and jobs accepted by the operator is restarted and control is transferred to the job interface process 36. If the operator did not use the Lunch or Break button 127 the last time they logged off the tablet application 24, then control is transferred to step 56 which displays a welcome screen 60 and starts an excess time clock for tracking the operator's time.

15 An example of a welcome screen 60 is shown in Fig. 5. The welcome screen 60 displays the name and clock number of the operator that successfully logged onto the tablet 18. The welcome screen 60 also displays a simulated Email button 66, a simulated Get New Job button 70, a simulated Code Elapsed Excess Time button 67, and a simulated Logout button 62. The tablet login process 34 then waits for the  
20 operator to select one of the Email button 66, the Get New Job button 70, the Code Elapsed Excess Time button 67, and the Logout button 62.

If the Code Elapsed Excess Time button 67 is selected, then step 69 is activated which transfers control to step 85. At step 85, the excess time process 43 is activated which allows the operator to enter a code for the excess time that has  
25 elapsed.

If the e-mail button 66 is selected, then step 68 is activated which transfers control to step 89. At step 89, the e-mail process 51 is activated which allows the operator to check his electronic mail.

If the Get New Job button 70 is selected, then step 72 is activated which  
30 transfers control to step 91. At step 91, the start new job process is activated which initiates the job initiation process 35.

If the Logout button 62 is selected, then step 64 is activated which checks to

-13-

see whether the operator has allocated their accumulated excess time. If excess time has accumulated above a predefined duration, for example 5 minutes, then the operator must allocate their excess time to a specific category before being able to log off of the tablet automation application 24. Otherwise, the operator can log off and

5 the accumulated excess time is allocated to a default category. If the operator must allocate some accumulated excess time, then at step 71, the tablet login process 34 displays a message indicating to the operator that they must allocate their excess time before logging off and, at step 73, control is transferred to the excess time process 43. If the operator does not need to allocate accumulated excess time, then control is

10 transferred to step 93. At step 93, the logout process is activated which logs the operator off of the tablet 18 and makes the tablet 18 available for use by another operator. The tablet automation application 24 also makes sure that all of the operator's jobs are stopped and their status entered as either complete or incomplete before allowing the operator to log off.

15 For each order number identifying a product order, a list of required operations to build the product is stored in the task descriptions database 27 and a list of the necessary parts for completing the order are stored in the parts list database 27. The Oracle Manufacturing Application can be used to assist in these operations. Other applications and modules can also be used to assist personnel at the command center

20 14 in tracking the completion of tasks and optimizing the use of available resources in the assignment of individual tasks to available operators and work centers. When the order is initiated, a bar code tag is created for each order number which is associated with the order throughout the manufacturing process.

The command center 14 allocates jobs to operators and an operator accepts a

25 job through the tablet automation application 24. The operator picks up the necessary parts with the associated order number for the assigned job at a central location, for example the stores window in the factory. When the operator is finished with the assigned task, whether it is complete or incomplete, the operator returns the parts and associated order identifier to the central location or to the next location for further

30 processing. An operator can be working on multiple orders at the same time. The tablet automation application 24 tracks counters, clocks and flags independently for each order being worked on by the operator. When an operator picks up an allocated

-14-

order at the stores window, he is assigned the order by scanning his operator bar code and the bar code associated with the allocated order. By knowing the orders that an operator has accepted and by knowing the tablet 18 that the operator has logged onto, the tablet automation application 24 knows the tablet to which each order is  
5 associated.

The job initiation process 35, represented in Fig. 6, tracks the assignment of jobs to operators, the acceptance of jobs by operators and the assignment of jobs to work centers. Upon entry to the job initiation process 35, at step 78, the system checks whether the operator has any unaccepted assigned jobs. Unaccepted assigned  
10 jobs are jobs which have been assigned to the operator, because the operator scanned the operator and order bar codes, but which the operator has not yet accepted or rejected in the tablet automation application 24. If there are no unaccepted assigned jobs for the operator then, at step 79, the job initiation process 35 displays a message on the tablet 18 indicating that there are no unaccepted assigned jobs for the operator  
15 and returns control to the calling process. If there are unaccepted assigned jobs for the operator then, at step 74, the job initiation process 35 displays the unaccepted assigned jobs for the operator. If the operator has multiple unaccepted assigned jobs, then a list of the unaccepted assigned jobs is displayed. When the operator has only one unaccepted assigned job or after the operator selects a job from the list of  
20 unaccepted assigned jobs, a jobs assigned screen 84 is displayed which contains information about an unaccepted assigned job that has been picked up by the operator logged onto the tablet 18. Fig. 7 shows an example of the jobs assigned screen 84. The jobs assigned screen 84 includes job information 86 such as order number, operation and job description. The jobs assigned screen 84 also includes a simulated  
25 Accept button 88 and a simulated Reject button 90.

If the operator rejects a job by selecting the Reject button 90, step 76 of the job initiation process 35 transfers control to step 74. At step 74, the tablet automation application 24 notifies the command center 14 that the job has been rejected and releases the job for assignment to another operator. The operator that rejected the job  
30 should also return any materials picked up for the job to the stores window for reassignment. Control is then returned to step 74 to display other unaccepted/unrejected assigned jobs to the operator on the tablet 18.

If the operator accepts a job by selecting the Accept button 88, the job initiation process 35 collects necessary data for tracking and supporting the job. At step 77, the job initiation process 35 retrieves data associated with the accepted job from the databases accessible through the tablet automation application 24. The data 5 would include the production steps to be performed, a list of SPC parameters which must be entered, the filenames of any SPC charts, the filenames of any sketches associated with the job, a list of parts for the job, and appropriate work centers for performing the job.

At step 80, the job initiation process 35 determines if a first piece inspection is 10 required for the selected job. A first piece inspection pop-up window 87, shown in Fig. 8, is displayed which includes a simulated Yes button 94 and a simulated No button 96. The operator determines whether a first piece inspection is required for the accepted job. The operator then indicates to the automated tablet application 24 whether or not a first piece inspection is required by selecting the Yes button 94 or the 15 No button 96, respectively. If the operator indicates that a first piece inspection is required by selecting the Yes button 94, the automated tablet application 24 stores that a first piece inspection is required for the selected operation and verifies that a first piece inspection is performed before the operation is marked as completed.  
At step 82, the job initiation process 35 displays a work center selection pop-up 20 window 98 in which the approved work centers for performing the job are displayed to the operator. An example of the work center selection window 98 is shown in Fig. 9. The work center selection window 98 includes a list of available work centers 100 and a simulated Accept button 102. The work centers can be ordered so that a primary work center 101 is displayed as the first entry in the list 100 of approved 25 work centers. At step 82, the operator selects a desired work center by highlighting the desired work center in the work center list 100 using the stylus 21, and selecting the Accept button 102.

After the operator makes the necessary selections in the job initiation process 35, the tablet application 24 transfers control to the job interface process 36 and the 30 time tracking process 38. The operator obtains the required raw stock or components from the factory stores or from the tool mover and proceeds to the selected work center with the tablet 18. The tablet application 24 also updates the databases on

-16-

server 12 to reflect the selections made by the operator during the job initiation process 35. This allows for real-time querying of information by managers concerning the status of jobs.

The job interface process 36 provides access to most of the other processes of  
5 the tablet automation application 24. The job interface process 36, represented in  
Figs. 10a- 10c, starts at step 104 by displaying a main job window. Fig. 11 shows an  
example of a main job window 106. The job window 106 includes a job information  
section 108, a job description list 107 of tasks to be performed in completing the  
selected job, and a job scroll bar 132. The job window 106 also includes several  
10 simulated buttons allowing the user to view job information and move between  
processes for any of the jobs selected by the operator. The simulated buttons include  
a view BOM button 110, a Dimension button 123, a Weld Alloy button 125, a Lunch  
or Break button 127, a Stop Job button 114, a Get New Job button 116, a View SPC  
button 128, a Start Excess button 121, a Start Setup button 120, a Start Production  
15 button 122, a First Piece Inspection button 124, a View Sketch button 126, and an  
Email button 130. The main job window 106 also displays a time status indicator 112  
which indicates to the user the category in which time is currently accumulating for  
the job displayed in the job information section 108.

As the main job window 106 is being displayed, the job interface process 36  
20 also sets up and displays the accepted job selection buttons at step 330. The accepted  
job selection buttons are displayed in the job scroll bar 132 which includes multiple  
job selection buttons 136 displaying identifying information for jobs that have been  
accepted by the operator. For example, the highlighted job selection button 136 in  
Fig. 11 contains the order number and part number for the job currently displayed in  
25 the job information section 108. For each job that has been accepted by the operator  
through the job initiation process 35, a job selection buttons 136 on the job scroll bar  
132 will contain identifying information about the accepted job. An operator can  
switch between the accepted jobs in the job scroll bar 132 by selecting the appropriate  
job selection button 136. When a different job selection button 136 is selected, the  
30 information in the job information section 108, the job description section 107, the  
time status indicator 112, and the simulated buttons of the main job window 106  
which are active change to the appropriate information and status for the newly

-17-

selected job. The job scroll bar 132 also includes a forward scroll button 137 and a backward scroll button 135. The scroll buttons 135, 137 are only active if there are more accepted jobs than there are job selection buttons 136 that can be displayed in the job scroll bar 132. For example, Fig. 11 shows five job selection buttons 136  
5 displayed in the job scroll bar 132. If the operator has not accepted more than five jobs, then the accepted jobs would be displayed in the displayed job control buttons 136 and the scroll buttons 135, 137 would not be active. Alternatively, if the operator has accepted more than five jobs, then the accepted jobs can not be displayed in the five displayed job control buttons 136 and at least one of the scroll buttons 135, 137  
10 would be active to provide the operator with access to the non-displayed jobs.

When the operator selects the View BOM button 110, step 332 of the job interface process 36 is activated and, at step 334, the job interface process 36 displays the bill of materials for the job which is currently displayed in the job information fields 108. If there is no bill of materials for the job which is currently displayed in  
15 the job information fields 108, then the view BOM button 110 will not be displayed in the main job window 106.

When the operator selects a different job from the job scroll bar 132, step 336 of the job interface process 36 is activated and, at step 338, the job interface process 36 updates the job information section 108, the job description list 107, the time status  
20 indicator 112, and the simulated buttons of the main job window 106 which are active to display information for the newly selected job.

When the operator selects the Get New Job button 116, step 340 of the job interface process 36 is activated and, at step 342, the job initiation process 35 is called. The job initiation process 35 was described above and is represented in Figs.  
25 6-9. By selecting the Get New Job button 116 from the main job view screen 106, the operator can initiate additional jobs concurrently with the already accepted jobs. It is frequent in a machine shop environment for an operator to be working concurrently on multiple jobs because of the programmability of modern tools, for example, a lathe. Therefore, the operator can program the lathe with the desired tool paths to  
30 create the part for one selected job and, while the lathe automatically carries out the provided instructions, the operator can be programming or performing another job. The job scroll bar 132 contains a job selection button 136 for each job accepted

-18-

through the job initiation process 35. The operator switches between accepted jobs using the job selection buttons 136.

When the operator selects the Start Setup button 120, step 344 of the job interface process 36 is activated and, at step 346, the job setup process 37 is called.

5 The job setup process 37, described in more detail below, tracks the time the operator spends setting up for the job which is currently displayed in the job information section 108 of the main job window 106.

When the operator selects the Start Production button 122, step 348 of the job interface process 36 is activated and, at step 350, the job production process 39 is

10 called. The job production process 39, described in more detail below, tracks the time the operator spends in production for the job which is currently displayed in the job information section 108 of the main job window 106.

Continuing with the representation of the job interface process 36 in Fig. 10b, when the operator selects the First Piece Inspection button 124, step 352 of the job  
15 interface process 36 is activated and, at step 354, the first piece inspection process 40 is called. The first piece inspection process 40, described in more detail below, confirms that a first piece inspection has been performed on the operation which is currently displayed in the job information section 108 of the main job window 106.

When the operator selects the View Sketch button 126, step 356 of the job  
20 interface process 36 is activated and, at step 358, the view sketch process 41 is called. The view sketch process 41, described in more detail below, is used to view sketches and schedules for the job which is currently displayed in the job information section 108 of the main job window 106.

When the operator selects the View SPC button 128, step 360 of the job  
25 interface process 36 is activated and, at step 362, the SPC data viewing process 44 is activated. The SPC data viewing process 44 displays a window with a list of SPC charts available for the job which is currently displayed in the job information section 108 of the main job window 106. There should be n charts available for viewing, where n is the number of SPC parameters that will be collected for the job. SPC  
30 charts are normally X-bar and R charts. The SPC data viewing process 44 allows the operator to view a selected SPC chart and to switch between available SPC charts for the job. Fig. 12 shows an example of an X-bar chart window 139 for one of the SPC

-19-

characteristics.

When the operator selects the Stop Job button 114, step 364 of the job interface process 36 is activated and, at step 366, the stop job process 46 is called.

The stop job process 46, described in more detail below, is used to when the job

5 which is currently displayed in the job information section 108 of the main job window 106 has been completed, reassigned, needs to be yellow-tagged or the operator's shift is over.

When the operator selects the e-mail button 130, step 368 of the job interface process 36 is activated which transfers control to step 370. At step 370, the e-mail

10 process 51 is called. The e-mail process 51 is used by the operator to receive and read electronic messages and bulletins. The e-mail process 51 displays an e-mail window on the tablet 18. An example of an e-mail window 320 is shown in Fig. 26. In the preferred embodiment, the e-mail process 51 does not enable the operator to generate and send e-mail messages. The e-mail process 51 can automatically delete messages  
15 that have aged in an operators queue after a certain number of days.

Continuing with the representation of the job interface process 36 in Fig. 10c, when the operator selects the Dimensions button 123, step 353 of the job interface process 36 is activated which transfers control to step 355. At step 355, a window is displayed for the operator to record dimensions of the part being produced for

20 tracking. For example, a gap distance of the part may be measured and recorded. When the operator selects the Weld/Alloy button 125, step 357 of the job interface process 36 is activated which transfers control to step 359. At step 359, a window is displayed for the operator to record weld or alloy lot numbers being used in the operation for tracking. The recorded data can then be archived and retrieved at a later  
25 time to determine the components that went into producing the part.

When the operator selects the Lunch/Break button 127, step 361 of the job interface process 36 is activated which transfers control to step 363. At step 363, time keeping for the operator and for all jobs accepted by the operator is suspended, and the operator is logged off of the tablet application 24. The jobs remain assigned to the

30 operator. When the operator logs back onto a tablet 18, the tablet application 24 will restart time keeping for the operator and for all jobs accepted by the operator and will start the operator directly in the job interface process 36 displaying the main job

-20-

window 106.

When the operator selects the Start Excess button 121, step 365 of the job interface process 36 is activated which transfers control to step 367. The Start Excess button 121 is only made available for selection when the operator has just one job in

5 setup or production. The Start Excess button 121 is used by the operator to indicate that the accepted job is not in either setup or production. At step 367, the job interface process 36 stops the setup or production clock for the job accepted by the operator, updates the setup or production time, and switches to excess time mode. The switch to excess time mode is evidenced by the time status indicator 112.

10 The job setup process 37, represented in Fig. 13, tracks the time the operator spends setting up the work center according to the instructions for the job which is displayed in the job information section 108 of the main job window 106 when the Start Setup button 120 is selected.

At step 372, the job setup process 37 determines whether excess time is

15 currently accumulating for the job. This would occur when the operator has accepted the job but has not started either setup or production for the job. If the operator is currently accumulating excess time then step 374 is activated. At step 374, the job setup process 37 stops the excess time clock and updates the accumulated excess time in the tablet automation system 24 and/or passes this information to an interfacing

20 time keeping system. Step 374 then transfers control to step 376 to start the setup time clock.

If the operator is not currently accumulating excess time then step 382 is activated. The operator would not be accumulating excess time when a job accepted by the operator is in either setup or production mode. At step 382, the job setup

25 process 37 determines whether production time is currently accumulating for the job. If production time is currently accumulating for the job then step 384 is activated, otherwise step 376 is activated. At step 384, the job setup process 37 stops the production time clock and updates the accumulated production time for the job in the tablet automation system 24 and/or passes this information to an interfacing time

30 keeping system. Step 384 then transfers control to step 376 to start the setup time clock.

At step 376, the start time is recorded for the setup clock and time begins to

-21-

accumulate as setup time for the selected job. At step 378, the job setup process 37 updates displays and indicators to indicate that the job is in setup mode, which would include changing the status indicator 112 to show Setup Time. Then at step 380 control is returned to the job interface process 36.

5       The job production process 39, represented in Fig. 14, tracks the time the operator spends performing the production operations specified in the job description list 107 of the main job window 106 when the Start Production button 122 is selected. At step 390, the job production process 39 determines whether excess time is currently accumulating for the job. This would occur when the operator has accepted  
10      the job but has not started either setup or production for the job. If the operator is currently accumulating excess time then step 392 is activated. At step 392, the job production process 39 stops the excess time clock and updates the accumulated excess time in the tablet automation system 24 and/or passes this information to an interfacing time keeping system. Step 392 then transfers control to step 394 to start  
15      the production time clock.

If the operator is not currently accumulating excess time then step 400 is activated. The operator would not be accumulating excess time when a job accepted by the operator is in either setup or production mode. At step 400, the job production process 39 determines whether setup time is currently accumulating for the job. If  
20      setup time is currently accumulating for the job then step 402 is activated, otherwise step 394 is activated. At step 402, the job production process 39 stops the setup time clock and updates the accumulated setup time for the job in the tablet automation system 24 and/or passes this information to an interfacing time keeping system. Step 402 then transfers control to step 394 to start the production time clock.

25       At step 394, the start time is recorded for the production clock and time begins to accumulate as production time for the selected job. At step 396, the job production process 39 updates displays and indicators to indicate that the job is in production mode, which would include changing the status indicator 112 to show Production Time. Then at step 398 control is returned to the job interface process 36.

30       The first piece inspection process 40 is used to confirm that a first piece inspection has been performed on a job. The operator initiates the first piece inspection process 40 by selecting the First Piece Inspection button 124 from the main

-22-

job window 106 shown in Fig. 11. A first piece inspection is often required for the first piece in a given lot of parts. If the first piece passes inspection, then other parts produced by the operator using the same production process are expected to meet the same criteria. After the first piece is produced, the operator takes the first piece and  
5 the tablet 18 to an inspection area to have a supervisor inspect the piece. If a first piece inspection is required for an operation, and the operator does not have a first piece inspection verified through the first piece inspection process 40, the operator will not be able to sign off on the job as being complete.

The first piece inspection process 40 is functionally represented in Fig. 15.

10 The first piece inspection process 40 is called from the job interface process 36 when the operator selects the First Piece Inspection button 124 from the main job window 106. At step 410, the first piece inspection process 40, displays a first piece inspection window 178, shown in Fig. 16, through which the supervisor verifies that he has inspected the first piece. The first piece inspection window 178 includes a  
15 keypad 180, a supervisor clock number field 182, a supervisor PIN number field 184, a simulated Accept button 186 and a simulated Cancel button 188. At steps 412 and 414, the first piece inspection process 40 checks whether the Accept button 186 or the Cancel button 188, respectively, have been selected.

The Cancel button 188 is used to exit the first piece inspection process 40  
20 without verification of a first piece inspection being performed on the selected job. When the Cancel button 188 is selected, then at step 414, control is transferred to step 416. Step 416 returns control back to the job interface process 36.

The Accept button 186 is used to verify that a first piece inspection has been performed on the selected job, and then to exit the first piece inspection process 40.  
25 After the first piece inspection has been completed, the supervisor enters his clock number in the supervisor clock number field 182 and enters his PIN number in the supervisor PIN number field 184 using the keypad 180. After the supervisor has entered his clock and PIN numbers, the Accept button 186 is selected. When the Accept button 186 is selected, step 412 transfers control to step 418. At step 418, the  
30 supervisor clock and PIN numbers are verified. If the supervisor clock or PIN number is incorrect, at step 420 an invalid verification message is displayed and the first piece inspection process 40 returns to wait for the Accept or Cancel button to be selected. If

the supervisor clock and PIN numbers are correct, at step 422 the first piece inspection process 40 records the first piece inspection for the selected job and the supervisors verification, and at step 416 control is returned to the job interface process 36.

5       The view sketch process 41 is used to view sketches or schedules associated with the selected job. The operator initiates the view sketch process 41 by selecting the View Sketch button 126 from the main job window 106 shown in Fig. 11. The View Sketch button 126 is only available for selection on the main job window 106 when there is a sketch associated with the job displayed in the job information section  
10 108. Statistical Process Control (SPC) measurements that need to be recorded for a particular operation are indicated on sketches with SPC hotspot icons. Sketches may or may not have SPC hotspots for SPC data collection associated with them. An example of a sketch 222 with SPC hotspots is shown in Fig. 19 and an example of a sketch 201 without SPC hotspots is shown in Fig. 18.

15       Fig. 18 shows a sketch window 200 which includes the sketch 201, a scroll/zoom control box 224, an item number control box 208, a close control 210, and SPC hotspots 202, 204, 206. By selecting the up, down, right or left pointing arrow in the scroll/zoom control box 224, the operator can scroll the sketch 222 up, down, right or left, respectively, in the sketch window 220 on the screen 19 of the  
20 tablet 18. By selecting the zoom box in the scroll/zoom control box 224, the operator can zoom in or zoom out on the sketch 222 in the sketch window 220 of the tablet 18 through a cycle of preset zoom levels. The item number control 208 indicates which item within a lot the sketch is being used for. By using the right and left arrows on the left side of the item number control box 208, the operator can look at sketch for  
25 the next or previous item in the lot, respectively. For example, if there are two items in a lot and SPC measurements need to be entered for each item in the lot, then the operator could enter SPC measurements for the first item, advance the item control number and enter SPC measurements for the second item. The SPC hotspots 202, 204, 206 are placed on the sketch next to dimensions which are to be measured and  
30 recorded for quality assurance and tracking. By selecting one of the SPC hotspots, the operator can enter an SPC measurement for the characteristic associated with the selected SPC hotspot. Prior to data entry, the SPC hotspot is displayed in a yellow

-24-

box, and after data entry it is displayed in a green box. This enables the operator to easily tell from the sketch which measurements have already been entered and which still need to be entered.

Fig. 19 shows a sketch window 220 which includes the sketch 222, the  
5 scroll/zoom control box 224, the item number control box 208, and the close control  
210. The scroll/zoom control box 224, the item number control box 208 and the close  
control 210 perform the same functions described with regard to Fig. 18. By selecting  
the close control 210, the operator can close the sketch and return to the main job  
screen 106 shown in Fig. 11.

10 A functional representation of the view sketch process 41 is shown in Fig. 17.  
The view sketch process 41 is activated when the operator selects the View Sketch  
button 126 on the main job window 106. The View Sketch button 126 is only  
available for selection if there is a sketch for the selected job. If there is more than  
one sketch for the job, the view sketch process 41 displays a list of sketches. The  
15 operator can then choose the desired sketch from the list. At step 430, the view sketch  
process 41 retrieves and displays the sketch associated with the selected job or the  
sketch selected from the list of sketches, and displays the control boxes for the sketch  
window 220. At step 432, the view sketch process 41 checks whether there are any  
SPC hotspots for the sketch. If there are any SPC hotspots, then, at step 434, the  
20 status of the SPC hotspots is determined and the SPC hotspots are displayed. The  
status is used to indicate to the operator whether or not an SPC measurement has been  
entered for a particular SPC hotspot. The view sketch process 41 then awaits a  
control selection by the operator.

If the operator selects one of the scroll arrows or the zoom control of the  
25 scroll/zoom control box 224, step 436 is activated which transfers control to step 438.  
At step 438, the view sketch process 41 scrolls or zooms the sketch in the sketch  
window 220. The view sketch process 41 then returns to await another control  
selection by the operator.

If the operator selects one of the arrows of the item number control 108, step  
30 440 is activated which transfers control to step 442. At step 442, the view sketch  
process 41 displays the sketch 201 for next or the previous item of the lot in the sketch  
window 220 depending on whether the right or left arrow, respectively, was selected.

-25-

The view sketch process 41 then returns to await another control selection by the operator.

If the operator selects one of the SPC hotspots 202, 204 or 206, step 444 is activated which transfers control to step 446. At step 446, the SPC data entry process

5 42 (described below) is called. After the SPC measurement has been entered, the view sketch process 41 then returns to await another control selection by the operator. If the operator selects the close sketch control 210, step 448 is activated which transfers control to step 449. At step 449, the sketch window 220 is closed and then, at step 450, control is returned to the calling process.

10 The SPC data entry process 42 is activated when an operator selects an SPC hotspot from a sketch window while in the view sketch process 41. Fig. 21 shows the same sketch 201 shown in Fig. 18 after the SPC hotspot 204 has been selected. When the SPC hotspot 204 is selected, the SPC data entry process 42 is activated which adds a numeric keypad 207 with a close icon 209 and an enter button 211, an outline appearance 210 to the hotspot 204 showing that it is currently active, and an SPC data entry field 212 which includes the name of the characteristic 216 associated with the SPC hotspot 204. The operator can enter the SPC data into data entry field 212 with stylus 21 and keypad 207.

15

Statistical process control, SPC, is used to verify that the critical dimensions of 20 a given lot of parts are within acceptable tolerances. It is the job of the operator to make sure that every  $n^{\text{th}}$  part, such as every twentieth part, of the lot meets the required tolerances.

A functional representation of the SPC data entry process 42 is shown in Fig. 20. When the operator selects an SPC hotspot, for example hotspot 204 in Fig. 18, the 25 SPC data entry process 42 is activated. At step 456, the numeric keypad 207 is added to the sketch window 200 (see Fig. 21). At step 458, the SPC measurement entry box 212 is displayed and the characteristic name 216 to be recorded is displayed in the SPC measurement entry box 212. The SPC data entry process 42 then waits for either the enter key 211 or the close icon 209 of the numeric keypad 207 to be selected by 30 the operator. Meanwhile, the operator uses the stylus 21 to enter an SPC measurement using the numeric keypad 207, to select the enter key 211, or to select the close icon 209.

-26-

The operator selects the enter key 211 after entering the SPC measurement in the SPC entry field 212. When the enter key 207 is selected, step 460 is activated which transfers control to step 464. At step 464, the SPC data entry process 42 records the SPC measurement entered in the SPC entry field 212 and changes the SPC  
5 status to recorded. When the SPC status for a hotspot is recorded, the color of the SPC hotspot on the sketch is green to indicate that a measurement has already been recorded for the SPC hotspot. Then at step 466, the SPC data entry process 42 returns control to the view sketch process 41.

The operator selects the close icon 209 to exit the SPC data entry process 42  
10 without entering an SPC measurement. When the close icon 209 is selected, step 462 is activated which transfers control to step 466. At step 466, the SPC data entry process 42 returns control to the view sketch process 41.

Since sketches 222 and associated data are often subject to change, operators are alerted when viewing a sketch 222 that has changed recently. When an operator  
15 presses the View Sketch button 126, a "View New Sketches" button 131 becomes available if the selected sketches 222 have changed. The operator presses the View New Sketches button 131 to view the new sketches 222. After a predetermined number of operations of the View New Sketch button 131, the View New Sketch button 131 no longer appears, thus ensuring that the operator is knowledgeable about  
20 the changes to sketch 222. Alternatively, instead of a View New Sketches button 131 appearing, the View Sketch button 126 toggles to contain the "View New Sketch" caption. After a predetermined number of operations, the View New Sketch caption disappears, thus ensuring that the operator is knowledgeable about the changes to sketch 222.

25 The tablet application 24 requires that the operator stop every active job before logging off of the tablet 18. The stop job process 46 is used by an operator to end his assignment to a job and to indicate the status of the job when he has completed his assignment. When a job is stopped, it is either a completed job or an incomplete job for at least one of a number of reasons. The operator initiates the stop job process 46  
30 by selecting the Stop Job button 114 of the main job window 106 shown in Fig. 11. A functional representation of the steps of the stop job process 46 are shown in Figs. 22a and continue into Fig. 22b. At step 470, the stop job process 46 displays a stop

-27-

job window. Fig. 23 shows an example of a stop job window 260. The stop job window 260 presents the operator with five simulated buttons from which to indicate the status of the stopped job. A complete button 262 is used to indicate that the job is complete. Incomplete buttons 264, 266 and 268 are used to indicate that the job is stopped but is still incomplete for some reason. The Unattended Operation button 269 functions the same as the complete button 262, except that the job is posted as complete only after the expiration of the entire standard time of the job, e.g. if the standard time for a job is 4 hours, and the operator stops the job as unattended after 2 hours, the job will be posted as complete after expiration of the 4 hour period.

10       The Incomplete-Shift Change button 264 is used to indicate that the operators shift ended before the job was completed. The Incomplete-Reassigned button 266 is used to indicate that the job or operator was reassigned before the job was completed. The Incomplete-Yellow Tag button 268 is used to indicate that the job was stopped due to some discrepancy. Of course other job status buttons could be made available

15       in the stop job window 260. If the operator has highlighted one of the incomplete buttons 264, 266, 268 then a simulated numeric keypad 274 is displayed for the operator to enter the number of items completed in an items completed field 272. If the operator highlights the complete button 262, the numeric keypad 274 is removed from the stop job window 260. The stop job window 260 also contains an Accept

20       button 276 which the operator uses to record his entries, a Cancel button 278 which the operator uses to return to the job interface process 36, and a Show Next Operation button 280 which the operator uses to have the tablet automation application 24 show the next operation to be performed on the parts in the currently selected job.

From the stop job window 260, the operator can switch between any of the

25       four status buttons 262, 264, 266, 268. An indicator 270 is used to indicate the job status currently selected. Alternatively, the status button could be highlighted, or changed in color to indicate that it is currently selected. At step 472, the stop job process 46 determines whether the currently selected job status button is the complete button 262 or one of the incomplete buttons 264, 266, 268. If the currently selected

30       job status button is one of the incomplete buttons 264, 266, 268, then the keypad 274 is displayed for the operator to enter the number of completed items. If the currently selected job status button is the complete button 262, then the keypad 274 is not

displayed.

At steps 474, 476 and 477; the stop job process 46 waits for the operator to select either the Accept button 276, the Cancel button 278 or the Show Next Operation button 280, respectively.

- 5        The Cancel button 278 is used to exit stop job process 46 without recording the status of the job and without ending the operators assignment to the job. When the Cancel button 278 is selected, step 476 is activated which transfers control to step 478. At step 478, the stop job process 46 returns control to the job interface process 36 and redisplays the main job window 106.
- 10      The Show Next Operation button 280 is used to show the next operation to be performed on the parts in the currently selected job. When the Show Next Operation button 280 is selected, step 477 is activated which transfers control to step 479. At step 479, the stop job process 46 displays a window showing the next operation to be performed on the parts in the currently selected job. The operator can view this information to determine where to transport the completed parts for further production. When the window showing the next operation is closed, the stop job process 46 returns to steps 474, 476 and 477 to again wait for the operator to select either the Accept button 276, the Cancel button 278 or the Show Next Operation button 280, respectively.
- 15      The Accept button 276 is used to record the job status entries entered by the operator. When the Accept button 276 is selected, step 474 is activated and the stop job process 46 uses steps 480, 482, 484, 486 to determine which of the four job status buttons was selected. If none of the four status buttons was selected, then step 486 transfers control to step 502. At step 502, the stop job process 46 displays a message for the operator to select a job status button, and control returns to steps 474, 476 and 477 to again wait for the operator to select either the Accept button 276, the Cancel button 278 or the Show Next Operation button 280, respectively.  
If the Incomplete-Shift Change button 264 is selected then step 480 is activated which transfers control to step 488. At step 488, the tablet application 24 records the operators identification and the status of the job as incomplete due to a shift change. Control is then transferred to step 490, where the tablet application 24 records the number of items completed from the items completed field 272, the end production
- 20
- 25
- 30

-29-

time for the job, and flags the job as incomplete. Control is then transferred to step 492 shown in Fig. 22b. At step 492, the stop job process 46 of the tablet application 24 determines whether the operator is assigned to any other jobs. If the operator is assigned to another job, then at step 494, the operator is returned to the job interface process 36 which displays the main job window 106 shown in Fig. 11. If the operator is not assigned to any other jobs, then at step 496, the operator is returned to the tablet login process 34 at entry point G which at step 56 displays the welcome window 60 shown in Fig. 5 from which the operator can choose a new job or logout of the tablet application 24.

10        If the Incomplete-Reassigned button 266 is selected then step 482 is activated which transfers control to step 498. At step 498, the tablet application 24 records the operators identification and the status of the job as incomplete due to a reassignment. Control is then transferred to step 490, where the tablet application 24 records the number of items completed from the items completed field 272, the end production time for the job, and flags the job as incomplete. Control is then transferred to step 492 shown in Fig. 22b. At step 492, the stop job process 46 of the tablet application 24 determines whether the operator is assigned to any other jobs. If the operator is assigned to another job, then at step 494, the operator is returned to the job interface process 36 which displays the main job window 106 shown in Fig. 11. If the operator is not assigned to any other jobs, then at step 496, the operator is returned to the tablet login process 34 at entry point G which displays the welcome window 60 shown in Fig. 5 from which the operator can choose a new job or logout of the tablet application 24.

15        If the Incomplete-Yellow Tag button 484 is selected then step 484 is activated which transfers control to step 500. At step 500, the stop job process 46 transfers control to the yellow tag process 50.

20        If the Complete button 266 is selected then step 486 is activated which transfers control to step 504. At step 504, the tablet application 24 checks that all necessary entries for completion of the job have been made by the operator including any required statistical process control (SPC) measurements and any required first piece inspections. If the required entries were not entered then control is transferred to step 506. At step 506, the stop job process 46 displays a message indicating the

-30-

entries which are still required for the job, and control returns to steps 474, 476 and 477 to again wait for the operator to select either the Accept button 276, the Cancel button 278 or the Show Next Operation button 280, respectively.

If the required entries were made then control is transferred to step 508 where

5 the tablet application 24 records the operator identification, the status of the job as complete, the end production time for the job, and flags the job as complete. Control is then transferred to step 492 where the stop job process 46 determines whether the operator is assigned to any other jobs. If the operator is assigned to another job, then at step 494, the operator is returned to the job interface process 36 which displays the

10 main job window 106 shown in Fig. 11. If the operator is not assigned to any other jobs, then at step 496, the operator is returned to the tablet login process 34 at entry point G which at step 56 displays the welcome window 60 shown in Fig. 5 from which the operator can choose a new job or logout of the tablet application 24.

The yellow tag process 50 is initiated by the operator when the piece is discrepant and

15 needs to be routed to inspection. A supervisors authorization is usually required to yellow-tag a job. Once a job has been yellow-tagged the parts from the job are routed to inspection where an inspector will review the parts and the entered yellow-tag information to determine whether the parts are unacceptable and a discrepancy report should be generated, or whether the parts are acceptable and the yellow-tag should be

20 cleared from the job.

A functional representation of the steps of the yellow tag process 50 are shown in Fig. 24. At step 510, the yellow tag process 50 displays the yellow tag window. Fig. 25 shows an example of a yellow tag window 300. The yellow tag window 300 presents the operator with multiple characteristic number fields 302 and multiple

25 actual measurement fields 304 for the entry of discrepant information for the parts. The characteristic numbers for the parts are shown in the sketches which can be viewed by selecting a view sketch button 320. The operator enters the discrepant characteristic number in the discrepant characteristic field 302 and the actual measurement of the discrepant characteristic in actual measurement fields 304. For

30 each discrepant characteristic the operator must enter an actual measurement for the characteristic. The operator can enter multiple discrepant characteristics and actual measurements for the yellow-tagged job. The yellow tag screen 300 also includes a

-31-

selectable miscellaneous defects field 306 and a defect cause field 308. Examples of a miscellaneous defects are dent, scratch, filled cells, etc. Examples of discrepancy cause include operator fault. When operator fault is selected in the cause field 308, an operator at fault field 312 is displayed in which the operators identification or clock 5 number is entered. A supervisor clock number field 310 is used for authorization of the yellow tag for the job. A simulated numeric keypad 314 is used to enter the data in the discrepant characteristic fields 302, the actual measurement fields 304, the supervisor clock number field 310, and the operator at fault field 312. The yellow tag screen 300 also includes an accept button 316 which is used to record the yellow tag 10 entries, and a cancel button 318 which the operator uses to return to the stop job process 46 which displays the stop job window 260 shown in Fig. 23.

The operator uses the keypad 314 to enter the appropriate values in the various numeric fields. At step 512, the yellow tag process 50 monitors a defect drop-down list selector 307. When the drop-down list selector 307 is selected, step 512 is 15 activated which transfers control to step 516. At step 516, the yellow tag process 50 displays a defect type drop down list from which the operator can select a defect type to be entered in the miscellaneous defect field 306. At step 514, the yellow tag process 50 monitors a cause list selector 309. When the cause list selector 309 is selected, step 514 is activated which transfers control to step 518. At step 518, the 20 yellow tag process 50 displays a cause drop down list from which the operator can select a cause to be entered in the cause field 308. At step 520, the yellow tag process 50 monitors the view sketch button 320. When the view sketch button 320 is selected, step 520 is activated which transfers control to step 522. At step 522, the yellow tag process 50 calls the view sketch process 41. The operator can find the 25 characteristic numbers to be entered in fields 302 on the sketch.

At steps 524 and 526, the yellow tag process 50 waits for the operator to select either the accept button 316 or the cancel button 318. The accept button 316 is used to record the yellow tag information entered by the operator. The Cancel button 318 is used to exit the yellow tag process 50 without recording the yellow tag information. 30 When the Cancel button 318 is selected, then 524 is activated which transfers control to step 528. At step 528, the yellow tag process 50 returns control to the stop job process 46 and redisplays the stop job window 260.

-32-

When the Accept button 316 is selected, step 526 is activated which transfers control to step 530. At step 530, the yellow tag process 50 checks whether a valid supervisor clock number is entered in the supervisor clock number field 310 and whether the required fields have been entered. If a valid supervisor clock number is 5 not entered or the required fields are not entered, then step 530 transfers control to step 532. At step 532, the yellow tag process 50 displays a message for the operator to enter a valid supervisor clock number and/or the required fields, and control is returned to wait for further operator input.

If a valid supervisor clock number and the required fields are entered, then 10 step 530 transfers control to step 534. At step 534, the tablet application 24 records the operator and supervisors identification, the yellow tag status, the end production time for the job, the number of items completed which was entered in the items completed field 272 of the end job window 260, the discrepancy information entered on the yellow tag window 300, flags the job as yellow tagged and enters it in the 15 yellow tag queue for review by an inspector. Control is then transferred to step 536. At step 536, the yellow tag process 50 of the tablet application 24 determines whether the operator has any other pending jobs. If the operator has another pending job, then at step 538, the operator is returned to the job interface process 36 which displays the main job window 106 shown in Fig. 11. If the operator does not have any other 20 pending jobs, then at step 540 the operator is returned to the tablet login process 34 at entry point G which at step 56 displays the welcome window 60 shown in Fig. 5 from which the operator can choose a new job or logout of the tablet application 24.

Throughout its operation the time tracking process 38 of the tablet automation application 24 tracks the operators time allocation to the various jobs accepted by the 25 operator and the operator's excess time which is not allocated to a job. In the described embodiment, time is allocated to either setup, production or excess time. In the time status indicator 112 of the main job window 106 shown in Fig. 11, the tablet automation application 24 displays, how time is currently being accumulated for the job. If an operator logged onto the tablet automation application 24 is not charging to 30 production or setup time for any job, then excess time is accumulating.

If excess time is accumulating and exceeds a predetermined duration, for example 5 minutes, the time tracking process 38 automatically activates the excess

-33-

time process 43. The excess time process 43 can also be activated by the operator from the welcome window 60, shown in Fig. 5, by selecting the Code Elapsed Excess button 67. A functional representation of the excess time process 43 is shown in Fig. 27. When the excess time process 43 is activated, either automatically or manually,

5       an excess time window is displayed at step 542. An example of an excess time window 168 is shown in Fig. 28. The excess time window 168 provides a category list 171 from which the operator can choose to charge the accumulated excess time, a simulated Accept button 170, and a simulated Cancel button 172. The operator selects a category for the accumulated excess time and then chooses the Accept button

10      170 to record the excess time allocation, or chooses the Cancel button 172 to avoid recording the excess time at this point. If the operator chooses the cancel button 172, excess time continues to accumulate and the operator will still be required to allocate the accumulated excess time to a category before logging off the tablet automation application 24. Accumulations of excess time which are less than the predetermined

15      duration can be charged to a default category, for example traveling.

When the Accept button 170 is selected, step 544 is activated and control is transferred to step 548. At step 548, the excess time process 43 records the selected category for the accumulated excess time. Then at step 550, control is returned to the previous process. When the Cancel button 172 is selected, step 546 is activated and

20      control is transferred to step 550. At step 550, control is returned to the previous process. The excess time process 43 can be called from various processes depending on what process is active when the excess time exceeds the predetermined duration and the tablet automation application 24 automatically activates the excess time process 43.

25      A discrepant material report ("DMR") can be initiated in different ways. An inspector can convert a job that has been yellow tagged into a DMR. Alternatively, an inspector can create and submit a new DMR. Once a DMR has been created, it is submitted to the discrepant material report station 16 (Fig. 1) for processing by the appropriate department, e.g. engineering. A DMR processing application 600 runs on

30      the discrepant material report station 16 (Fig. 1).

A top-level functional representation of the steps of the DMR processing application 600 are shown in Fig. 29. At step 602, the DMR processing application 600 presents

-34-

the user with a logon screen through which the application verifies the user identity and authorization. At step 604, after the user successfully logs on, the DMR processing application 600 presents the user with a list of DMRs from which to select a DMR for processing. At step 606, the DMR processing application 600 presents the 5 user with information about the selected DMR and options and support for the disposition of the selected DMR. Dispositions for a DMR could include rework, use as is, return to vendor, send to customer material review board, or scrap. At step 608, the DMR processing application 600 ensures that the DMR disposition receives the proper approvals, e.g. by both a manufacturing engineer and a quality engineer. Once 10 the disposition has been approved, at step 610, the DMR processing application 600 moves any rework operations into production. At step 612, the DMR processing application 600 either automatically flags or prompts the user as to whether to flag the DMR for a root cause investigation, depending on the dispositions of the DMR. At step 614, the DMR processing application 600 closes the DMR.

15       The DMR processing application 600 has a logon screen with fields for the entry of a user name and a password. This information is used to determine the identity of the user and to determine whether they are authorized to use the application. When a user successfully logs on, the DMR processing application 600 displays a DMR selection window from which the user can choose a DMR for 20 processing. An example of a DMR selection window 620 is shown in Fig. 30. The DMR selection window 620 includes a submitted DMR list 622, a current user login information section 624, a legend section 626, an Edit button 628, a Change Password button 630, a Close button 632 and an MRB button 634.

25       For each DMR, the submitted DMR list 622 includes: a DMR identifier which is a unique number assigned to each DMR, a date on which the DMR was written, the time in hours that have elapsed since the DMR was created, the part number the DMR is associated with, the number of undisposed items in the DMR, a manufacturing engineer (ME) approval field, a quality engineer (QE) approval field, a user name field, and the order number the DMR is associated with. The number of undisposed 30 items in the DMR must be zero before the DMR can be closed. The user field is blank unless another user has already selected the DMR for processing. If another user has already selected the DMR, then their user name will be displayed in the user

field for the DMR.

The current login information section 624 contains the user name and the user type for the user that is currently logged on the DMR application 600. For example, in Fig. 30 the current user is a quality engineer, thus the current user could provide  
5 quality engineer approval but not manufacturing engineer approval.

The legend section contains identification information for determining the status of a DMR in the submitted DMR list 622. In the DMR selection window 620 shown in Fig. 30, the legend section 626 shows two background colors for showing the DMR status. A DMR with a light background is an open DMR, and a DMR with  
10 a dark background is a DMR that was given a disposition that was rejected during the approval step 608 (Fig. 29).

The Change Password button 630 allows the user to change their password. The new password would be used to logon in subsequent sessions on the DMR application 600. The Close button 632 is used to close the DMR selection window  
15 620.

The MRB button 634 allows the user to view or hide DMRs that have been dispositioned to the customer material review board (MRB). When the MRB button 634 displays the identifier "Show MRB" (see Fig. 30), the submitted DMR list 622 displays the submitted DMRs which have not been dispositioned to the MRB. When  
20 the Show MRB button 634 is selected, the submitted DMR list 622 displays only DMRs that have been dispositioned to the MRB and hides the other DMRs, and the identifier displayed on the DMR button 634 changes to "Hide MRB." When the Hide MRB button 634 is selected, the submitted DMR list 622 displays only non-MRB DMRs and hides the DMRs that have been dispositioned to the MRB, and the  
25 identifier displayed on the DMR button 634 changes back to "Show MRB."

A user can select a DMR for processing by either double-clicking on the DMR in the submitted DMR list 622, or by highlighting the DMR in the submitted DMR list 622 and then selecting the Edit button 628. When the user selects a DMR for processing, the DMR application 600 displays a DMR view window 640. An  
30 example of a DMR view window 640 is shown in Fig. 31.

The DMR view window 640 displays all of the information available about the selected DMR. The DMR view window 640 includes a header information section

-36-

642, a disposition summary section 644, a dispositions created section 646, a Delete button 648, a Void DMR button 650, a View Rework button 652, a Save button 654, and a Main Menu button 656.

The DMR header section 642 contains general information regarding the 5 currently selected DMR. The values in the DMR header section 642 are entered by the operator and supervisor during the yellow-tag process 50, and by the inspector during inspection and processing of the yellow-tagged parts. The information in the DMR header section 642 includes the unique DMR identifier, the manufacturing order number the DMR is associated with, the operation that triggered the DMR, the 10 part number the DMR is associated with, the cause of the discrepancy as determined by the supervisor, the part defect responsible for the DMR, the operator at fault for the defect, the work center at which the defect occurred, an otherwise OK field which indicates whether the inspector determined that all other characteristics of the parts were within specifications, the serial number of the defective part, the sample size 15 inspected, the quantity or lot size of the manufacturing order, the quantity of parts in the order rejected by the inspector, and a discrepancy description field which contains a textual description of the discrepancy as entered by the inspector.

The dispositions summary section 644 displays a summary of the dispositions of the parts associated with the DMR. The dispositions summary section 644 includes 20 an undisposed field and a plurality of disposition fields. The undisposed field indicates the number of parts in the DMR that have not yet had a disposition assigned to them. Initially, the undisposed field has the same value as the quantity rejected in the DMR header section 642. The disposition fields shown in the DMR view window 640 include: Use As Is, Rework, Scrap, RTV (return to vendor), and MRB (send to 25 customer material review board). The value in each disposition field indicates how many parts have been assigned that particular disposition. The sum of the undisposed field and the disposition fields equals the value in the quantity rejected field in the DMR header section 642. A DMR cannot be closed until all of the parts are given a disposition, i.e. the value in the undisposed field is zero. For example, if the quantity 30 rejected is 10 pieces, and 3 have been given a disposition of "rework", 4 have been given a disposition of "use as is," and 1 has been given a disposition of "return to vendor," then the values in the disposition summary section 644 would be: 2 in the

-37-

undisposed field, 4 in the "Use As Is" field, 3 in the "Rework" field, 0 in the "MRB" field, 0 in the "Scrap" field, and 1 in the "RTV" field.

When an engineer selects a disposition of "Use As Is", the engineer's name is recorded in the manufacturing routing as the completing operator. This allows the

5 parts to be tracked to the engineer who approved the parts for use.

The fields in the disposition summary section 644 also function as buttons that are selectable by the user to input values for the amount of items that are to receive the selected disposition. When the user selects a disposition field button in the disposition summary section 644, a DMR disposition window is displayed. An

10 example of a DMR disposition window 660 is shown in Fig. 32.

The DMR disposition window 660 includes a disposition from field 662, a disposition to field 664, a number of parts transferred field 666, an order ID field 668, a comment field 670, a submit button 672 and a cancel button 674. The disposition to field 662 and the disposition from field 664 are pull down menus which include

15 entries for each of the fields in the disposition summary section 644. The disposition from field 662 defaults to Undisposed. The disposition to field 664 displays the entry of the disposition field button in the disposition summary section 644 that was selected by the user. The order ID field 668 defaults to the order number associated with the DMR. The user can change the disposition from field 662, the disposition to

20 field 664, or the order ID field 668. The user enters the number of parts to receive the selected disposition in the number transferred field 666, and enters any necessary comments in the comments field 670. When the user selects the Submit button 672,

the entries in the DMR disposition window 660 are recorded in the dispositions

created section 646 of the DMR view window 640 and the DMR disposition window 25 660 is closed. When the user selects the Cancel button 674, the DMR disposition window 660 is closed and none of the entries are recorded.

Upon submitting a disposition for an item in the DMR disposition window 660, an entry is created in the dispositions created section 646 of the DMR view window 640. Each entry in the dispositions created section 646 includes the date

30 when the disposition was created, the information entered in the DMR disposition window 660, a manufacturing engineer (ME) approval field 658, and a quality engineer (QE) approval field 659. The Delete button 648 allows a user to delete an

-38-

entry in the dispositions created section 646. When a user highlights an entry in the dispositions created section 646 and selects the Delete button 648, the entry is removed from the dispositions created section 646 and the disposition summary section 644 is updated to show the status of the dispositions without the deleted entry.

5 A disposition can not be deleted once it has been approved.

When a disposition is submitted, it has not yet been approved by either a quality engineer or a manufacturing engineer. Before the disposition becomes active, it must be approved by both a manufacturing engineer and a quality engineer. To approve a disposition, the user selects the appropriate approval field. If the current 10 user does not have the appropriate authorization for the selected approval, then the DMR application 600 will display a pop-up window for entry of a user name and password with the proper authorization. If the current user has the appropriate authorization for the selected approval, then the DMR application 600 will display a pop-up window asking for confirmation of the approval. When all of the pieces 15 included in the DMR have a disposition and all of the dispositions have been approved, pieces given a rework disposition will be routed to production for completion of the rework by an operator.

The Main Menu button 656 allows the user to return to the DMR selection window 620. The Save button 654 allows the user to save any data that has been 20 changed in the DMR header section 642. The information regarding dispositions in the disposition summary section 644 and the dispositions created list 646 is automatically saved whenever the user enters new disposition information. The Void DMR button 650 allows the user to void or delete the entire DMR. The Void DMR button 650 is only activated to be selectable by the user if none of the 25 items associated with the DMR have a disposition, i.e. all of the items are undisposed. The View Rework button 652 allows the user to review and edit the steps to be performed in the rework operations for the pieces in the selected entry of the dispositions created list 646. When the user highlights an entry in the dispositions created section 646 and selects the View Rework button 652, a rework operations 30 window showing the steps to be performed in the rework of the parts is displayed. An example of a rework operations window 680 is shown in Fig. 33.

The rework operations window 680 shows the steps to be performed in the

-39-

rework of particular parts that were included in a DMR. The rework operations window 680 includes a rework operations list 682, a legend section 684, a Close button 686, an Edit button 688, a Copy button 690, a Delete button 692, a Mode button 694, a Mode field 695, a Sketches button 696 and a Resources button 698. The

5 Close button 686 allows the user to close the rework operations window 680 and return to the view DMR window 640.

The legend section 684 shows the identifiers that are used to distinguish between the steps in the rework operations list 682. In the Rework operations window 680 shown in Fig. 33, the legend section 684 shows four background colors for

10 indicating the four categories of the operations in the rework operations list 682. The "Completed Operations" category indicates operations that were part of the production process which have already been performed on the parts. The "Completed Rework Operations" category indicates operations that were part of a rework process which have already been performed on the parts. The "Rework Operations" category

15 indicates operations that are part of a rework process which have not been performed on the parts. The "Operations Not Yet Performed" category indicates operations that are part of the production process which have not been performed on the parts. Using the legend 684, the DMR application 600 indicates that the first operation (operation 100) is a completed rework operation, the next operations (operations 200-1400) are

20 completed operations, the next operations (operations 1401-1404) are rework operations that have not yet been performed, and the remaining operations (operations 1500-1950) are operations that have not yet been performed.

When the user highlights an operation in the rework operations list 682 and selects the Edit button 688, the system allows the user to edit the operation selected in

25 the rework operations list 682. When the user highlights one or more operations in the rework operations list 682 and selects the Delete button 692, the system deletes the selected operations from the rework operations list 682.

The rework operations list 682 includes a blank line at the bottom of the list at which the user can add an additional operation. The user would type entries in the

30 fields and select enter on the keyboard of the DMR Station 16. The DMR application 600 will then place the added operation in the rework operations list 682 according to the operation number. The reworks operations list 682 is kept in order according to

-40-

operation number.

The Mode button 694 allows the user to switch between single-select and multi-select modes. The mode field 695 shows the current mode. In multi-select mode, the user can select multiple operations from the rework operations list 682 for 5 copying or deleting. In the single-select mode the user can only select a single operation at a time from the rework operations list 682 for copying and deleting.

The Copy button 690 allows the user to copy one or more operations from the rework operations list 682 into new rework operations with new operation sequence numbers. When the user highlights operations in the rework operations list 682 and 10 selects the Copy button 690, the system copies the selected operations and displays a pop-up copy operations window. An example of a copy operations window is shown in Fig. 34. The copy operations window 700 includes a list of copied operations 702, a starting operation field 704, an OK button 706 and a Cancel button 708. The list of copied operations 704 shows the current operation numbers for the selected operations 15 from the rework operations list 682. The starting operation field 704 is where the user inserts the new starting operation number for the copied operations. The operations in the rework operations list 682 are listed in numeric order, and the copied operations will be renumbered to fit in the numeric order starting from the number entered in the starting operation field 704. When the user selects the OK button 706, the DMR 20 application 600 renames the operation sequence numbers of the copied operations to fit in numeric order starting from the number entered in the starting operation field 704; inserts the copied operations into the rework operations list 682; and closes the copy operation window 700. When the user selects the Close button 708, the DMR application 600 closes the copy operation window 700 without copying any 25 operations.

The Sketches button 696 allows the user to add sketches to a selected operation in the rework operations list 682. When the user highlights an operation in the rework operations list 682 and then selects the Sketches button 696, the DMR application 600 displays an operation sketches window showing the sketches 30 associated with the highlighted operation. An example of an operation sketches window 710 is shown in Fig. 35. The operation sketches window 710 includes a list of sketches 712, a Close button 714, an Add button 716, a Delete button 718, and a

-41-

View Sketch button 719. For each sketch associated with the operation, the list of sketches 712 shows the file name, the sketch name, and the date the sketch was created.

The Close button 714 allows the user to close the operation sketches window  
5 710. The Delete button 718 allows the user to delete the association of a selected sketch with the operation. The user first selects a sketch in the list of sketches 712 and then selects the Delete button 718, the DMR application 600 then removes the selected sketch from the list of sketches 712 and removes the association of the selected sketch with the operation. The View Sketch button 719 allows the user to  
10 view a sketch listed in the list of sketches 712. The user first selects a sketch in the list of sketches 712 and then selects the View Sketch button 719, the DMR application 600 then displays a sketch window similar to the sketch windows 200 and 220 shown in Figs. 19 and 21, respectively.

The Add button 716 allows the user to add sketches to be associated with the  
15 operation. When the user selects the Add button 716, the DMR application 600 displays an add sketch window. An example of an add sketch window 720 is shown in Fig. 36. The add sketch window 720 includes a sketch name field 722, a magnifying glass icon 723, a sketches found list 724, a sketch file name field 726, an OK button 727, a Cancel button 728, and a View Sketch button 729.

20 The user enters a portion of a file name in the sketch name field 722. The user does not need to enter a complete file name in the sketch name field 722. When the user selects the magnifying glass icon 723, the DMR application 600 searches all sketches for any sketch that contains the text entered in the sketch name field 722 and returns the results in the sketches found list 724. The user can then select a sketch in  
25 the sketches found list 724. The sketch filename field 726 contains the filename of the sketch selected in the sketches found list 724. The View Sketch button 729 allows the user to view a sketch listed in the sketches found list 724. The user first selects a sketch in the sketches found list 724 and then selects the View Sketch button 729, the DMR application 600 then displays a sketch window similar to the sketch windows  
30 200 and 220 shown in Figs. 19 and 21, respectively. The OK button 727 allows the user to add a sketch to be associated with the operation. The user first selects a sketch in the sketches found list 724 and then selects the OK button 727, the DMR

application 600 then adds the selected sketch to the list of sketches 712 in the operation sketches window 710 and closes the add sketch window 720. The Cancel button 728 allows the user to close the add sketch window 720 without adding a sketch to be associated with the operation.

5       The rework operations window 680, shown in Fig. 33, also includes the Resources button 698 which allows the user to add resources, for example a work center or a machine, to a selected operation in the rework operations list 682. When the user highlights an operation in the rework operations list 682 and then selects the Resources button 698, the DMR application 600 displays an operation resources window showing the resources associated with the highlighted operation. An example of a operation resources window 730 is shown in Fig. 37. The operation resources window 730 includes a list of resources 732, a Close button 734, an Add button 736, and a Delete button 738. For each resource associated with the operation, the list of resources 732 shows the resource sequence number, the resource name, the estimated hours for the operation on the resource, and the date the resource was added to the operation.

10      15

The Close button 734 allows the user to close the operation resources window 730. The Delete button 738 allows the user to delete the association of a selected resource with the operation. The user first selects a resource in the list of resources 732 and then selects the Delete button 738, the DMR application 600 then removes the selected resource from the list of resources 732 and removes the association of the selected resource with the operation.

20

The Add button 736 allows the user to add resources to be associated with the operation. When the user selects the Add button 736, the DMR application 600 displays an add resource window. An example of an add resource window 720 is shown in Fig. 38. The add resource window 740 includes a resource name field 742, a resource sequence number field 744, an estimated time field 745, an OK button 746, and a Cancel button 748. The resource name field 742 and the resource sequence number field 744 are associated with pull-down lists from which the user selects the desired entries. The user can then enter an estimated time in the estimated time field 745. When the user selects the OK button 746, the DMR application 600 adds the resource information entered in the add resource window 740 into a resource listed in

25

30

-43-

the list of resources 732 in the operation resources window 730 and closes the add resource window 740. When the user selects the Cancel button 748, the DMR application 600 closes the add resource window 740 without adding a resource to be associated with the operation.

5       The DMR application 600 will automatically flag a DMR for root cause investigation if any of the items of the DMR have been given a disposition of MRB or scrap. If a root cause investigation is initiated, the DMR will be included on a root cause investigation report.

A DMR is automatically closed by the DMR application 600 when the  
10 following conditions have been met: (1) all items in the DMR have been disposed of through one of the five disposition types; (2) no item in the DMR currently has a disposition of MRB; and (3) all dispositions for the DMR have been approved. When a DMR is being closed and it has not already been flagged for a root cause investigation, the DMR application 600 will display a window asking the user  
15 whether they want to have a root cause investigation performed for the DMR. If a root cause investigation is initiated, the DMR will be included on a root cause investigation report.

An SPC hotspots application 800 allows a user to view sketches associated with a part and operation, to add new SPC (Statistical Process Control) hotspots to an  
20 operation, to associate SPC hotspots with quality characteristics of an operation and to delete SPC hotspots from an operation. SPC hotspots are used in the tablet automation application 24 to collect quality data through the tablet 18 during production. The SPC hotspots application 800 runs on the SPC Parameter setup station 13 (Fig. 1).

25       An SPC hotspot represents a quality measurement that an operator is to take for a given part in an operation which is part of the production process. When a hotspot is created, it is associated with a particular quality collection plan and quality collection element. A quality collection element is essentially a characteristic that is to be measured by the operator and recorded. When an operator views a sketch 200  
30 (Fig. 18) for an operation to which SPC information is to be collected, a small SPC icon 202, 204, 206 appears on the sketch 200. When the operator selects one of the SPC hotspots 204 (see Fig. 21), the tablet automation application 24 displays a field

212 for the entry of measurement information for the quality characteristic associated with the selected SPC hotspot. When an SPC hotspots has been created for a given operation, an operator will not be able to complete the operation until the SPC measurement information has been entered.

5 A top-level functional representation of the steps of the SPC hotspot application 800 is shown in Fig. 39. At step 802, the SPC hotspot application 800 presents the user with a logon screen through which the application verifies the user identity and authorization. At step 804, after the user successfully logs on, the user selects a part for which SPC hotspot information is to be updated. At step 806, the  
10 user selects an operation in the production of the selected part for which SPC hotspot information is to be updated. At step 812, the updated SPC hotspot information is saved for use during production by the automated tablet application 24.

After the user successfully logs on, the SPC hotspot application 800 displays an SPC sketch selection window. An example of an SPC sketch selection window 820 is shown in Fig. 40. The SPC sketch selection window 820 includes a part number field 822, an operation sequence number field 824, and an image list 826, an OK button 828, and a Cancel button 829. The part number field 822 and the operation sequence number field 824 are pull down menus which include entries from which the user can select. The user first selects a part number in the part number field  
15 822. The SPC hotspot application 800 automatically updates the pull down menu of the operation sequence number field 824 to match the operation sequence numbers for the part selected in the part number field 822. The user then selects an operation sequence number in the operation sequence number field 824. The SPC hotspot application 800 automatically displays a list of images associated with the selected  
20 part number and operation sequence number in the image list 826. The user can then select a sketch from the image list 826 on which SPC information is to be edited. When the user selects the OK button 828, the SPC hotspot application 800 displays the selected image in an SPC sketch window and closes the SPC sketch selection window 820. When the user selects the Cancel button 748, the SPC hotspot  
25 application 800 closes the SPC sketch selection window 820 without opening a sketch.

An example of an SPC sketch window 830 is shown in Fig. 41. The SPC

sketch window 830 includes a sketch 831 selected through the SPC sketch selection window 820, an add SPC hotspots icon 832, a select or arrow icon 834, a save icon 836 and a magnifying glass icon 838. The functions described below which are initiated by each of the icons can also be initiated by selecting a corresponding item  
5 from the windows drop-down menus. The selected sketch 831 includes any associated SPC hotspots already associated with the sketch 831. An associated SPC hotspot is already associated with a quality characteristic of the part. The SPC hotspot application 800 provides a visual indication on the sketch 831 that an SPC hotspot is associated with a quality characteristic. For example, associated SPC hotspots can be  
10 displayed in a different color from non-associated SPC hotspots. The sketch 831 shows six SPC hotspots 840-850.

The draw SPC hotspots icon 832 initiates a function which puts the SPC hotspot application 800 in a add hotspot mode which allows the user to drop SPC hotspots at desired locations on the sketch 831. When the SPC hotspot application  
15 800 is in the add hotspot mode, the mouse pointer changes into an SPC icon 840. The user then positions the mouse pointer on the sketch where they would like a new SPC hotspot to appear and clicks the mouse to drop a non-associated SPC hotspot at the current mouse pointer position. The newly dropped SPC hotspot is not yet associated with a quality characteristic. The SPC hotspot application 800 remains in the add  
20 hotspot mode and the user can continue to move the mouse pointer and drop additional SPC hotspots on the sketch 831.

By choosing the select or arrow icon 834, the user can exit the add SPC hotspot mode. When the user selects the arrow icon 834, the SPC hotspot application exits the add SPC hotspot mode and the mouse pointer changes back into an arrow.  
25 The SPC hotspots 840-850 appear in one color when they are first created and in another color after they have been associated with a quality characteristic. This is a visual indication to the user as to whether they need to associate a quality characteristic with a particular SPC hotspot. The SPC hotspots cannot be saved unless they have a quality characteristic associated with them.  
30 To associate a quality characteristic with an SPC hotspot, the user must exit the add SPC hotspot mode and select an SPC hotspot on the sketch 831. When the user selects an SPC hotspot, the SPC application 800 displays a quality

-46-

characteristics window. An example of a quality characteristics pop up window 852 is shown in Fig. 42. The quality characteristics window 852 includes an SPC characteristic field 854 for association with the selected SPC hotspot, an SPC characteristic drop-down list button 856, an OK button 858 and a Cancel button 860.

5     The SPC characteristic drop-down list button 856 is used to activate a list of available SPC characteristics from which the user can select an SPC characteristic for the SPC characteristic field 854. A quality characteristic cannot be associated with more than one SPC hotspot. Thus, once a characteristic is associated with a hotspot, the SPC application 800 will not include the characteristic in the list of available SPC

10    characteristics. The user enters the name of an available SPC characteristic in the SPC characteristic field 854. Alternatively, the user can select the SPC characteristic drop-down list button 856 which displays a list of available SPC characteristics, and then select an SPC characteristic which will automatically fill in the SPC characteristic field 854. When the user selects the OK button 858, the SPC hotspots

15    application 800 associates the quality characteristic in the SPC characteristic field 854 with the selected SPC hotspot. If the selected SPC hotspot was previously unassociated with a quality characteristic, the visual indication of the selected SPC hotspot will change to indicate that it is associated with a quality characteristic. When the user selects the Cancel button 860, the SPC hotspots application 800 closes the

20    quality characteristics pop up window 852 without associating a quality characteristic with the selected SPC hotspot.

The user can also delete an SPC hotspot from the sketch 831. To delete an SPC hotspot from the sketch 831, the user selects the SPC hotspot they wish to delete and then presses the delete key on the keyboard of the SPC Parameter Setup Station

25    13. The SPC hotspots application 800 will then display a window for the user to confirm that they wish to delete the selected SPC hotspot. If the user confirms that they wish to delete the hotspot, the SPC hotspot will be deleted from the sketch and any associated quality characteristic will become unassigned and will then appear on the list of available quality characteristics 854 to be available for association with

30    another SPC hotspot.

Once all of the SPC hotspots have been associated with a quality characteristic, the sketch 831 with the associated SPC hotspots can be saved. The

sketch with the associated SPC hotspots is saved by selecting the save icon 836 from the SPC sketch window 830.

To close the SPC sketch window 830 the user selects the close window icon 839. When the user selects the close window icon 839, the SPC hotspot application 800 first checks to see if any unsaved changes have been made by the user. If there are no unsaved changes, the SPC application 800 closes the SPC sketch window 830 and returns to the SPC sketch selection window 820. If there are unsaved changes, the SPC hotspot application 800 displays a window asking the user if they wish to save changes before exiting. If the user does not wish to save changes, the SPC application 800 closes the SPC sketch window 830 and returns to the SPC sketch selection window 820. If the user indicates they wish to save changes, the SPC application 800 checks that all SPC hotspots are associated with a quality characteristic. If all SPC hotspots are associated with a quality characteristic, the SPC application 800 saves the changes, closes the SPC sketch window 830 and returns to the SPC sketch selection window 820. If some SPC hotspots are not associated with a quality characteristic, the SPC application 800 displays a message indicating that there are SPC hotspots not associated with a quality characteristic and returns the user to the SPC sketch window 830.

When an operator is working on a part during a job, and a DMR is issued of particular importance, or an alert is issued by an appropriate department (e.g., engineering), an alert screen 900 is generated, as shown in Fig. 44. Engineering can generate alerts using an Engineering Alert Notification via the server 12. Engineers flag a given order and operation for an alert, and specify the text of the alert. When the operator accepts that operation and order on the tablet 18, the operator receives the alert screen as shown in Fig. 44. At this point, an e-mail is also generated to the engineer that created the alert. Once the alert is acknowledged, the operator may continue with the operation.

Finally, transactions on tablet 18 are logged to a file on server 12. Illustratively, each separate transaction is logged to a separate storage file. Thus, one file stores DMR creations, another file stores rework operations, etc.

In an alternative embodiment of the present invention, a factory floor tablet automation system 10 includes access to the server 12 via a network 1014.

Illustratively, the network 1014 is the internet. Of course, one of ordinary skill in the art will recognize that any network may be used, such as a LAN, WAN, etc. A standard web browser application is implemented in tablets 18a - 18n, as shown in Fig. 43. Each tablet unit 18a-18n includes an antenna 20a-20n. A local processor 5 1012 is connected to the transceivers 22a-22m which are distributed throughout the factory. The tablet units 18a-18n communicate with the local processor 1012 through transceivers 22a-22m. Local processor 1012 communicates with server 12 via the network 1014, or other equivalent communication means. Note that in the illustrative embodiment, one of ordinary skill in the art will appreciate that local processor 1012 10 can be a server, a router, or other internet gateway. Thus, a number of remote manufacturing facilities may be linked to server 12 via local processors 1012 and network 1014.

By linking local processor 1012 to server 12, the tablet automation system can be implemented at several remote locations and still maintain data synchronization 15 with the server 12. Thus, all of the data operations described with respect to the exemplary embodiment of Fig. 1 apply to the alternative embodiment of Fig. 43. Additionally, by utilizing a common browser, procedures and documentation regarding operations may be viewed remotely on each tablet 18.

Of course, one of ordinary skill in the art will recognize that local processor 20 1012 may also be a server, and a job may be assigned to an operator at the facility through the local processor 1012. Information and transactions may then be logged to server 12 located in a central location.

In another illustrative embodiment, as shown in Fig. 45, a workstation 11 is connected to server 12 via a LAN or other similar network. The workstation 11 is 25 used in conjunction with the plurality of tablets 18. Illustratively, workstation 11 is a PC. The workstation 11 may run a software program to provide similar functionality of the tablet 18. Thus, the login process, accepting and receiving jobs, and all other operations facilitated by tablet 18 are likewise facilitated by workstation 11.

Workstation 11 can be located near a job site, such as a lathe, welding station, 30 or other factory job site.

Screen prints from a particular embodiment of the invention have been used in the description set forth above to aid in understanding the process which is part of the

-49-

present invention, and not by way of limitation to the particular embodiment shown. While a preferred embodiment of the invention is set forth above and shown in the drawings, those skilled in the art will recognize that various modifications can be made to the system disclosed in this application without departing from the spirit and  
5 scope of the invention as set forth in the claims attached hereto.

I claim:

1. A factory floor tablet automation system for storing manufacturing data, for collecting and processing manufacturing data generated throughout a facility during manufacturing, and for making manufacturing data accessible from various locations throughout the facility; the factory floor tablet automation system comprising:
  - a server computer having a processor unit and storage device; said storage device maintaining a plurality of databases including a job assignment database, an operator assignment database, a job description database, a drawing repository, a process control database, and a time keeping database;
  - a plurality of portable tablet devices, each of said plurality of portable tablet devices having a processor unit, a memory device, a display screen, an input/output device and a tablet antenna; and
  - one or more transceivers located throughout the facility, each transceiver being connected to said server computer; said plurality of portable tablet devices being in wireless communication with said server computer through said transceivers and said tablet antennas;wherein a job is assigned to an operator in the facility and one of said plurality of portable tablet devices is allocated to said operator; said operator accessing and receiving information from said server computer and said storage device through said allocated one of said plurality of portable tablet devices; said server computer receiving, storing and processing information from said operator through said allocated one of said plurality of portable tablet devices for tracking a status of said job and for tracking time allocation of said operator.
2. The factory floor tablet automation system of claim 1, further comprising a command center having a processor unit, a display device, and an input device; said command center communicating with said server computer; said command center being used to populate said plurality of databases, to retrieve information from said plurality of databases, and to determine said job status and said operator time allocation.
3. The factory floor tablet automation system of claim 2, further comprising a bar code printer and a bar code reader; said bar code printer

-52-

dispositions includes an investigate disposition, wherein, when said investigate disposition is selected and said investigate disposition is approved, said discrepant material report station automatically initiates an investigation.

8. The factory floor tablet automation system of claim 1, further  
5 comprising a statistical process control (SPC) parameter setup station having a processor unit, a display device, and an input device; said SPC station communicating with said server computer; said SPC station enabling a user to add an SPC data entry point by positioning an SPC icon for said SPC data entry point on a sketch associated with an SPC job and associating a quality characteristic of said SPC job with said  
10 SPC data entry point.

9. The factory floor tablet automation system of claim 8, wherein one of said plurality of said portable tablet devices displays said SPC icon for said SPC data entry point when said sketch is displayed on said one of said plurality of said portable tablet devices, and enabling said operator to enter SPC data for said quality  
15 characteristic of said SPC job by selecting said SPC icon of said SPC data entry point on said one of said plurality of said portable tablet devices.

10. The factory floor tablet automation system of claim 8, further comprising a discrepant material report station having a processor unit, a display device, and an input device; said discrepant material report station communicating with said server computer; discrepant material reports being communicated to said discrepant material report station; each of said discrepant material reports identifying a discrepant material uncovered during processing of said jobs; said discrepant material report station tracking proposed disposition of said discrepant material identified in each of said discrepant material reports, tracking approval of said  
20 proposed disposition.  
25

11. A method of collecting, processing, storing and accessing information for a plurality of jobs being performed by a plurality of operators in a facility, the method comprising the steps of:

storing job information for said plurality of jobs on a central computer  
30 having a processor unit and a storage device;  
allocating one of a plurality of portable computing devices to one of said plurality of operators; each of said plurality of portable computing devices having

-53-

a processor unit, a memory device, a display device, an input/output device and an antenna, and each of said plurality of portable computing devices communicating wirelessly with said central computer;

5 assigning at least one of said plurality of jobs to an assigned operator of said plurality of operators;

associating an assigned computing device of said plurality of portable computing devices with said at least one of said plurality of jobs using the information from said assigning step and said allocating step;

10 making said job information for said at least one of said plurality of jobs accessible by said assigned operator through said assigned computing device;

collecting, storing and processing manufacturing information for each of said plurality of jobs on said central computer, said manufacturing information for said at least one of said plurality of jobs being entered by said assigned operator on said assigned computing device; and

15 tracking time allocation of each of said plurality of operators to one or more phases of each of said plurality of jobs, said time allocation for said at least one of said plurality of jobs by said assigned operator being based upon entries made by said assigned operator on said assigned computing device.

12. The method of claim 11, wherein the assigning step comprises the  
20 steps of:

allotting an allotted job of said plurality of jobs to an allotted operator of said plurality of operators;

querying said allotted operator through said one of said plurality of portable computing devices allocated to said allotted operator to either accept or reject  
25 said allotted job;

making said allotted operator into an assigned operator for said allotted job only when said allotted operator indicates on said one of said plurality of portable computing devices allocated to said allotted operator that said allotted operator accepts said allotted job.

30 13. The method of claim 11 further comprising the steps of:

providing to said assigned operator, on said assigned computing device, a selection of available work centers for performing one of said at least one of

-54-

said plurality of jobs;

receiving said assigned operator's work center choice from said selection of available work centers through said assigned computing device; and  
allocating said work center to said operator for performing said one of  
5 said at least one of said plurality of jobs.

14. The method of claim 11 wherein said manufacturing information includes first piece inspection data, the method further comprising the steps of:  
querying said assigned operator through said assigned portable computing device to indicate whether a first piece inspection is to be performed on  
10 one of said at least one of said plurality of jobs;  
receiving said assigned operator's indication of whether a first piece inspection is to be performed on said one of said at least one of said plurality of jobs through said assigned computing device;  
when said operator indicates that a first piece inspection is to be  
15 performed on said one of said at least one of said plurality of jobs, not permitting said assigned operator to indicate completion of said one of said at least one of said plurality of said jobs until first piece inspection data is entered for said one of said at least one of said plurality of said jobs.

15. The method of claim 11 further comprising the steps of:  
20 displaying a job information window on said assigned computing device which shows job information for one of said at least one of said plurality of jobs, and a job scroll bar having a job selection button for each of said at least one of said plurality of jobs; and  
enabling said assigned operator to select a selected job of said at least  
25 one of said plurality of jobs for which job information is shown in said job information window by selecting said job selection button for said selected job.

16. The method of claim 15 wherein said job information shown in said job information window includes said time allocation information for said selected job.  
30 17. The method of claim 15, wherein said manufacturing information includes a plurality of sketches, each of said plurality of sketches being associated with one or more of said plurality of jobs, and said job information window includes a

-55-

simulated view sketch button, the method further comprising the step of:

enabling said assigned operator to select a selected sketch of said plurality of sketches by selecting said view sketch button, said selected sketch being associated with said selected job, and

5                 displaying said selected sketch on said assigned computing device when said assigned operator selects said selected sketch.

18.         The method of claim 17, wherein said manufacturing information includes statistical process control data and a plurality of SPC data entry points, each of said SPC data entry points being associated with at least one of said plurality of  
10 sketches; the method further comprising the steps of:

displaying an available SPC data entry point of said plurality of SPC data entry points on said assigned computing device when said operator selects said selected sketch and said available SPC data entry point is associated with said selected sketch;

15                 enabling entry of said SPC data for said selected job through said assigned computing device when said assigned operator selects said SPC data entry point, and

not permitting said assigned operator to indicate completion of said selected job until said SPC data is entered for said selected job.

20         19.         The method of claim 15, wherein said job information window includes a simulated break button, wherein said allocating one of a plurality of portable computing devices step includes the steps of:

accepting identification information on one of said plurality of portable computing devices from an entering operator of said plurality of operators;

25                 determining whether said entering operator has suspended tracking of said time allocation, and when tracking of said time allocation is suspended, resuming tracking of said time allocation for all of said at least one of said plurality of jobs,

the method further comprising the step of:

enabling said assigned operator to suspend tracking of said time  
30 allocation for all of said at least one of said plurality of jobs by selecting said break button.

20.         The method of claim 15, wherein said job information window

-56-

includes a simulated work phase button for a particular job phase for which said time allocation is tracked, the method further comprising the steps of:

collecting said time allocation data in said particular job phase for said selected job when said assigned operator selects said work phase button.

5 21. The method of claim 15, wherein said job information window

includes a stop job button enabling said assigned operator to indicate end of assignment of said selected job, the method further comprising the steps of:

when said assigned operator selects said stop job button, querying said assigned operator on said assigned computing device to indicate whether said selected 10 job is complete or incomplete;

when said assigned operator indicates said selected job is complete, checking that all necessary manufacturing information has been entered for said selected job and not permitting complete status for said selected job unless all necessary manufacturing information has been entered; flagging said selected job as 15 complete; and removing said selected job from said at least one of said plurality of jobs assigned to said assigned operator; and

when said assigned operator indicates said assigned job is incomplete, collecting and storing manufacturing information through said assigned computing device related to the status of said selected job.

20 22. A factory floor tablet automation system for storing, collecting and processing manufacturing data generated at a facility during manufacturing, and for making manufacturing data accessible from the facility, comprising:

a local processor at the facility;

25 a plurality of portable tablet devices, each of the plurality of portable tablet devices having a processor unit, a memory device, a display screen, an input/output device and a tablet antenna;

one or more transceivers located throughout the facility, each transceiver being connected to the local processor in the facility; the plurality of portable tablet devices being in wireless communication with the local processor

30 through the transceivers and the tablet antennas; and

a server computer having a processor unit and storage device; the storage device maintaining a plurality of databases; the server connected to the local

processor through a network.

23. The system of claim 22, further comprising a command center having a processor unit, a display device, and an input device; the command center communicating with the server computer; the command center being used to populate 5 the plurality of databases, and to retrieve information from the plurality of databases.

24. The system of claim 23, wherein a job is assigned to an operator in the facility and one of the plurality of portable tablet devices is allocated to the operator, the operator accessing and receiving information from the server computer and the storage device through the allocated one of the plurality of portable tablet devices; the 10 server computer receiving, storing and processing information from the operator through the allocated one of the plurality of portable tablet devices for tracking a status of the job and for tracking time allocation of the operator.

25. The system of claim 24, wherein the server stores manufacturing procedures and documentation, and wherein the portable tablet devices access the 15 manufacturing procedures and documentation through the local processor and network.

26. The system of claim 24, wherein the server is configured to issue an alert specific to the job, and wherein the alert is sent to all portable tablets allocated to operators to which the job is assigned.

20 27. The system of claim 22, wherein a job is assigned to an operator in the facility and one of the plurality of portable tablet devices is allocated to the operator, the operator accessing and receiving information from the server computer and the storage device through the allocated one of the plurality of portable tablet devices; the server computer receiving, storing and processing information from the operator 25 through the allocated one of the plurality of portable tablet devices for tracking a status of the job and for tracking time allocation of the operator.

28. The system of claim 27, wherein the server stores manufacturing procedures and documentation, and wherein the portable tablet devices accesses the manufacturing procedures and documentation through the local processor and 30 network.

29. The system of claim 28, wherein the server is configured to issue an alert specific to the job, and wherein the alert is sent to all portable tablets allocated to

operators to which the job is assigned.

30. The system of claim 22, further comprising a statistical process control (SPC) parameter setup station having a processor unit, a display device, and an input device; the SPC station communicating with the server computer; the SPC station enabling a user to add an SPC data entry point by positioning an SPC icon for the SPC data entry point on a sketch associated with an SPC job and associating a quality characteristic of the SPC job with the SPC data entry point.

31. The system of claim 30, wherein the server is further configured to notify the operator when data associated with a sketch has changed.

10 32. A method of collecting, processing, storing and accessing information for a plurality of jobs being performed by a plurality of operators in one or more facilities connected through a network, the method comprising the steps of:

storing job information for the plurality of jobs on a central computer having a processor unit and a storage device;

15 wirelessly linking a plurality of portable computing devices to a local processor in each facility;

linking each of the local processors in each facility to the central computer;

20 allocating one of the plurality of portable computing devices to one of the plurality of operators;

associating an assigned computing device of the plurality of portable computing devices with the at least one of the plurality of jobs;

making the job information for the at least one of the plurality of jobs accessible by the assigned operator through the assigned computing device; and

25 collecting, storing and processing manufacturing information for each of the plurality of jobs on the central computer.

33. The method of claim 32, wherein the step of storing job information for the plurality of jobs on a central computer having a processor unit and a storage device includes the step of storing sketch data associated with one of the plurality of 30 jobs.

34. The method of claim 33, wherein the step of collecting, storing and processing manufacturing information for each of the plurality of jobs on the central

computer includes the step of notifying the one of the plurality of operators of sketch data changes associated with the one of the plurality of jobs.

35. The method of claim 32, wherein the step of collecting, storing and processing manufacturing information for each of the plurality of jobs on the central computer includes the steps issuing an alert specific to the one of the plurality of jobs, and wherein the alert is sent to at least one of the plurality of portable computing devices associated with the one of the plurality of jobs.

36. The method of claim 32, wherein the step of storing job information for the plurality of jobs on a central computer having a processor unit and a storage device includes the step of storing manufacturing procedures and documentation.

37. The method of claim 36, further comprising the step of accessing the manufacturing procedures and documentation from one of the plurality of portable computing devices.

38. The method of claim 37, wherein the step of storing job information for the plurality of jobs on a central computer having a processor unit and a storage device includes the step of storing sketch data associated with one of the plurality of jobs.

39. The method of claim 38, wherein the step of collecting, storing and processing manufacturing information for each of the plurality of jobs on the central computer includes the step of notifying the one of the plurality of operators of sketch data changes associated with the one of the plurality of jobs.

40. The method of claim 39, wherein the step of collecting, storing and processing manufacturing information for each of the plurality of jobs on the central computer includes the steps issuing an alert specific to the one of the plurality of jobs, and wherein the alert is sent to at least one of the plurality of portable computing devices associated with the one of the plurality of jobs.

41. The method of claim 34, wherein the step of collecting, storing and processing manufacturing information for each of the plurality of jobs on the central computer includes the steps issuing an alert specific to the one of the plurality of jobs, and wherein the alert is sent to one of the plurality of portable computing devices associated with the one of the plurality of jobs.

42. A factory floor tablet automation system for storing, collecting and

-60-

processing manufacturing data generated at a facility during manufacturing, and for making manufacturing data accessible from the facility, comprising:

a workstation having a processor unit, a memory device, a display screen, and an input/output device;

5 a server computer having a processor unit and storage device; the storage device maintaining a plurality of databases; the server connected to the workstation through a network.

43. The system of claim 42, wherein a job is assigned to an operator in the facility and the workstation is allocated to the operator, the operator accessing and 10 receiving information from the server computer and the storage device through the allocated workstation; the server computer receiving, storing and processing information from the operator through the allocated workstation for tracking a status of the job and for tracking time allocation of the operator

44. The system of claim 43, further comprising:

15 a plurality of portable tablet devices, each of the plurality of portable tablet devices having a processor unit, a memory device, a display screen, an input/output device and a tablet antenna; and

one or more transceivers located throughout the facility, each transceiver being connected to the server computer; the plurality of portable tablet 20 devices being in wireless communication with the server computer through the transceivers and the tablet antennas.

45. The system of claim 44, wherein a job is assigned to an operator in the facility and one of the plurality of portable tablet devices is allocated to the operator; the operator accessing and receiving information from the server computer and the 25 storage device through the allocated one of the plurality of portable tablet devices; the server computer receiving, storing and processing information from the operator through the allocated one of the plurality of portable tablet devices for tracking a status of the job and for tracking time allocation of the operator.

46. The system of claim 42, further comprising:

30 a local processor at the facility;

a plurality of portable tablet devices, each of the plurality of portable tablet devices having a processor unit, a memory device, a display screen, an

-61-

input/output device and a tablet antenna; and

one or more transceivers located throughout the facility, each transceiver being connected to the local processor in the facility; the plurality of portable tablet devices being in wireless communication with the local processor through the transceivers and the tablet antennas;

wherein the server is connected to the local processor through a network.

47. The system of claim 46, wherein a job is assigned to an operator in the facility and one of the plurality of portable tablet devices is allocated to the operator; the operator accessing and receiving information from the server computer and the storage device through the allocated one of the plurality of portable tablet devices; the server computer receiving, storing and processing information from the operator through the allocated one of the plurality of portable tablet devices for tracking a status of the job and for tracking time allocation of the operator.

15 48. A manufacturing data system for use in a manufacturing facility, comprising:

a first computer having a processor and storage device, the storage device maintaining a database, the database storing manufacturing related data;

20 a plurality of tablet devices located throughout the facility, each of the tablet devices having a processor, a memory device, a display screen, and a tablet antenna; one or more transceivers located throughout the facility, each transceiver connected to the first computer, the plurality of tablet devices in wireless communication with the first computer through the transceivers and tablet antennas.

49. The system of claim 48, wherein a job is assigned to an operator in the facility and one of the plurality of tablet devices is allocated to the operator, the operator accessing and receiving information from the first computer through the allocated one of the plurality of tablet devices; the first computer receiving, storing

-62-

and processing information from the operator through the allocated one of the plurality of tablet devices for tracking a status of the job and for tracking time allocation of the operator.

50. The system of claim 49, wherein the first computer stores manufacturing procedures and documentation, and wherein the tablet devices access the manufacturing procedures and documentation.

51. The system of claim 49, wherein the first computer is configured to issue an alert specific to the job, and wherein the alert is sent to all tablets allocated to the operators to which the job is assigned.

10 52. The system of claim 48, further comprising a second computer having a processor and storage device, the second computer maintaining a database storing manufacturing related data, the second computer connected to the first computer through a network.

53. The system of claim 52, wherein a job is assigned to an operator in the facility and one of the plurality of tablet devices is allocated to the operator, the operator accessing and receiving information from the first and second computers through the allocated one of the plurality of tablet devices; the second computer receiving, storing and processing information from the operator through the allocated one of the plurality of tablet devices for tracking a status of the job and for tracking 20 time allocation of the operator.

54. The system of claim 53, wherein the second computer stores manufacturing procedures and documentation, and wherein the tablet devices access the manufacturing procedures and documentation.

55. The system of claim 53, wherein the first computer is configured to

-63-

issue an alert specific to the job, and wherein the alert is sent to all tablets allocated to the operators to which the job is assigned.

56. The system of claim 53, wherein the second computer is configured to issue an alert specific to the job, and wherein the alert is sent to all tablets allocated to  
5 the operators to which the job is assigned.

1/49

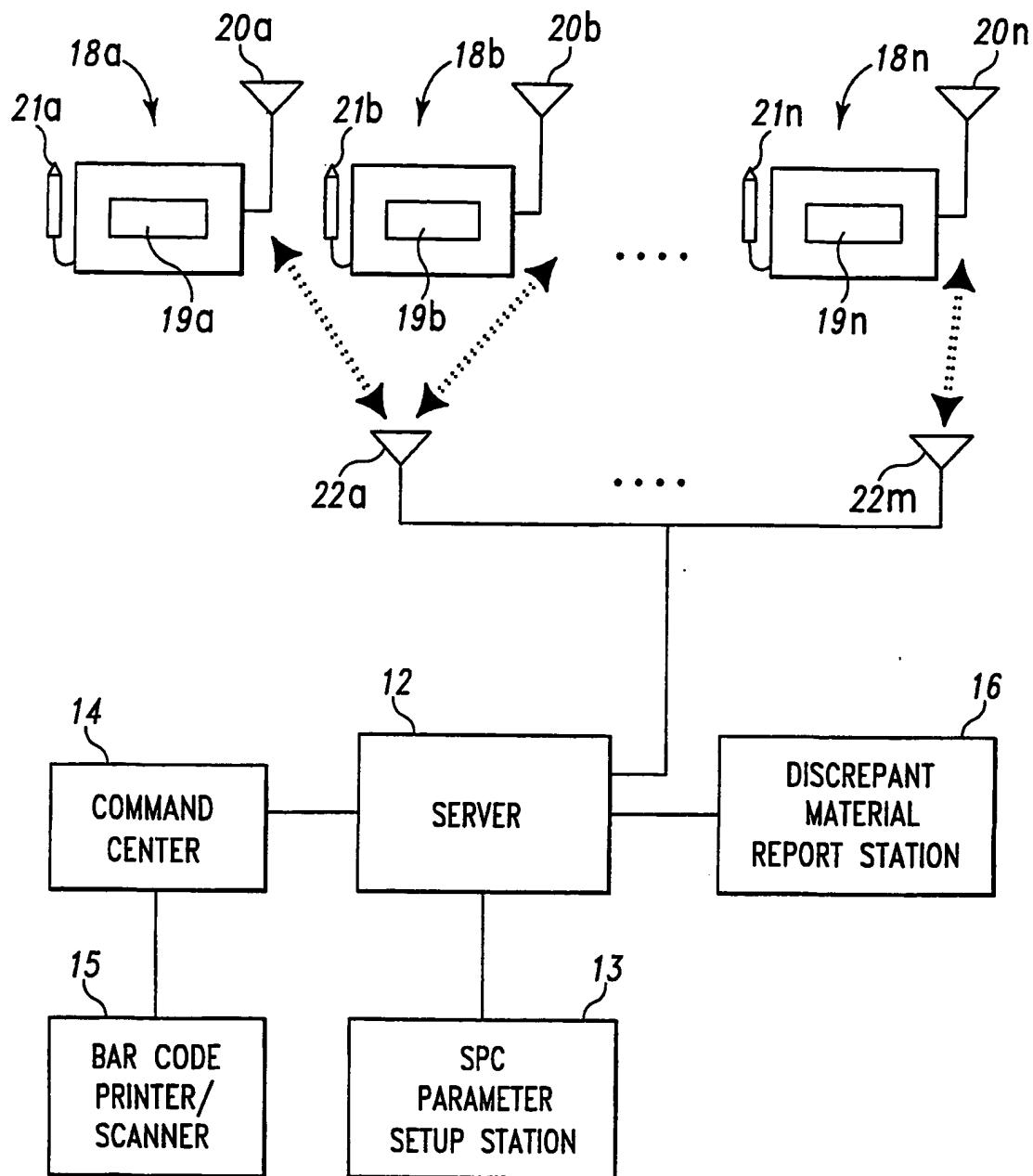


Fig. 1

2/49

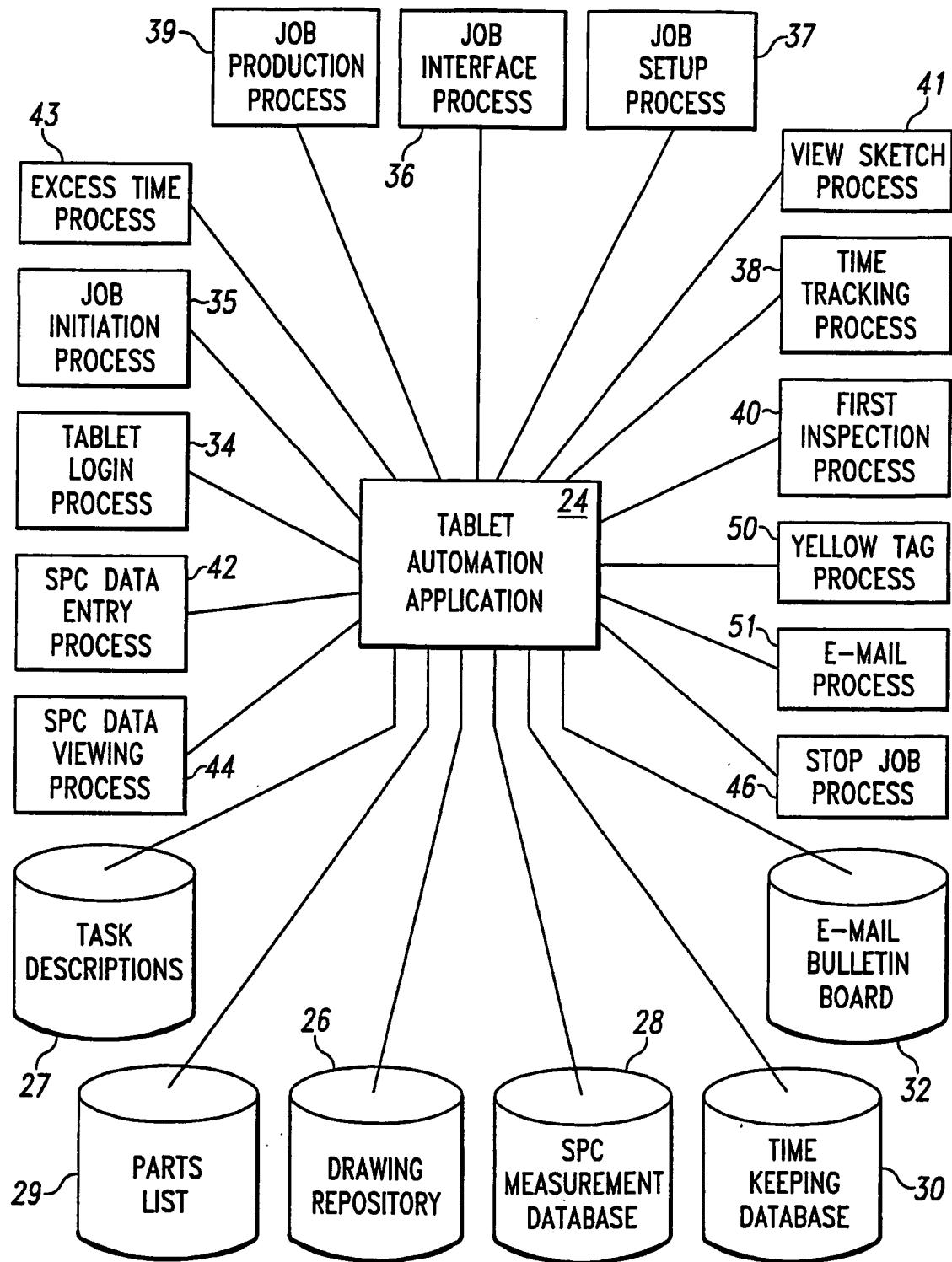


Fig. 2

3/49

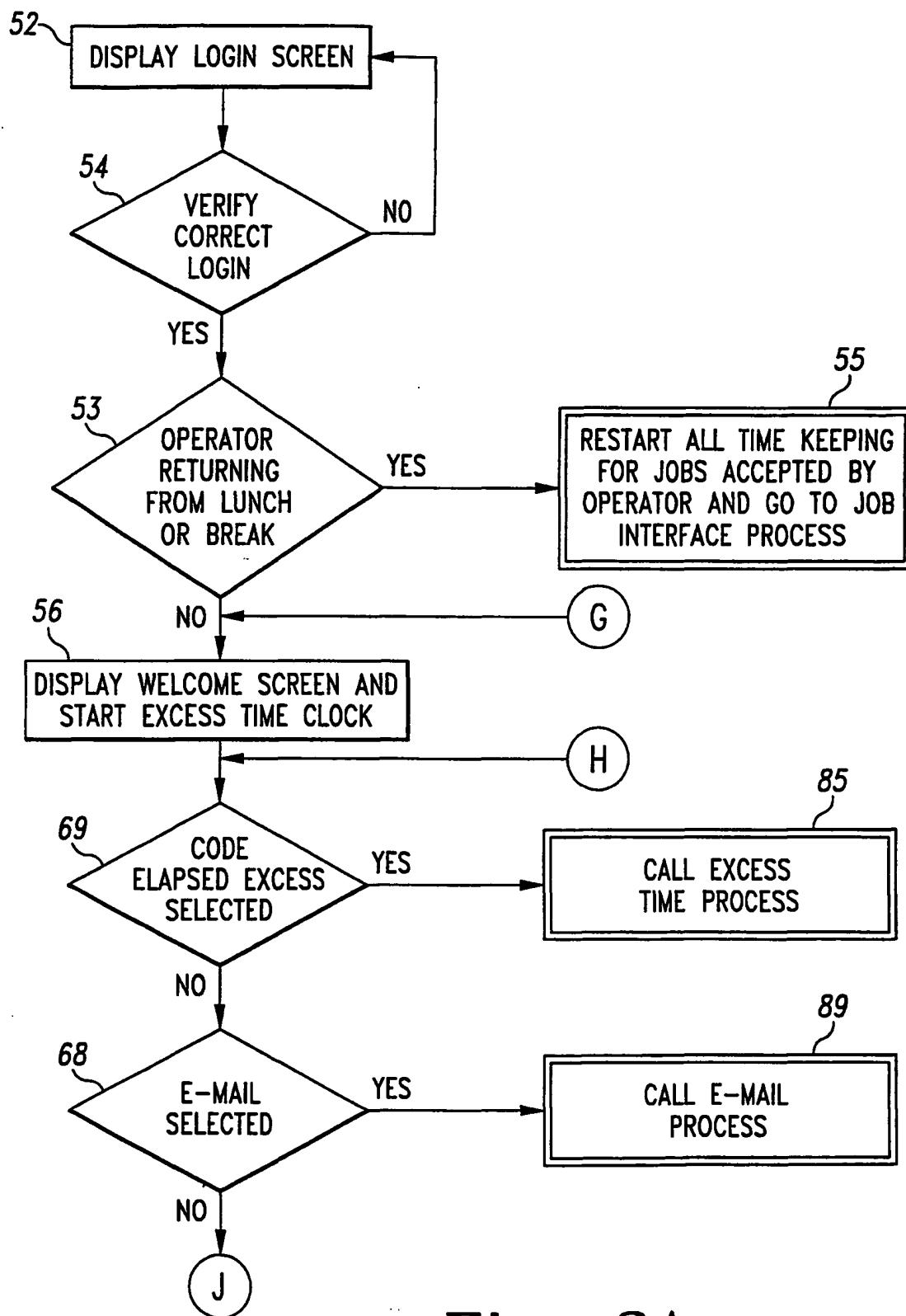


Fig. 3A

4/49

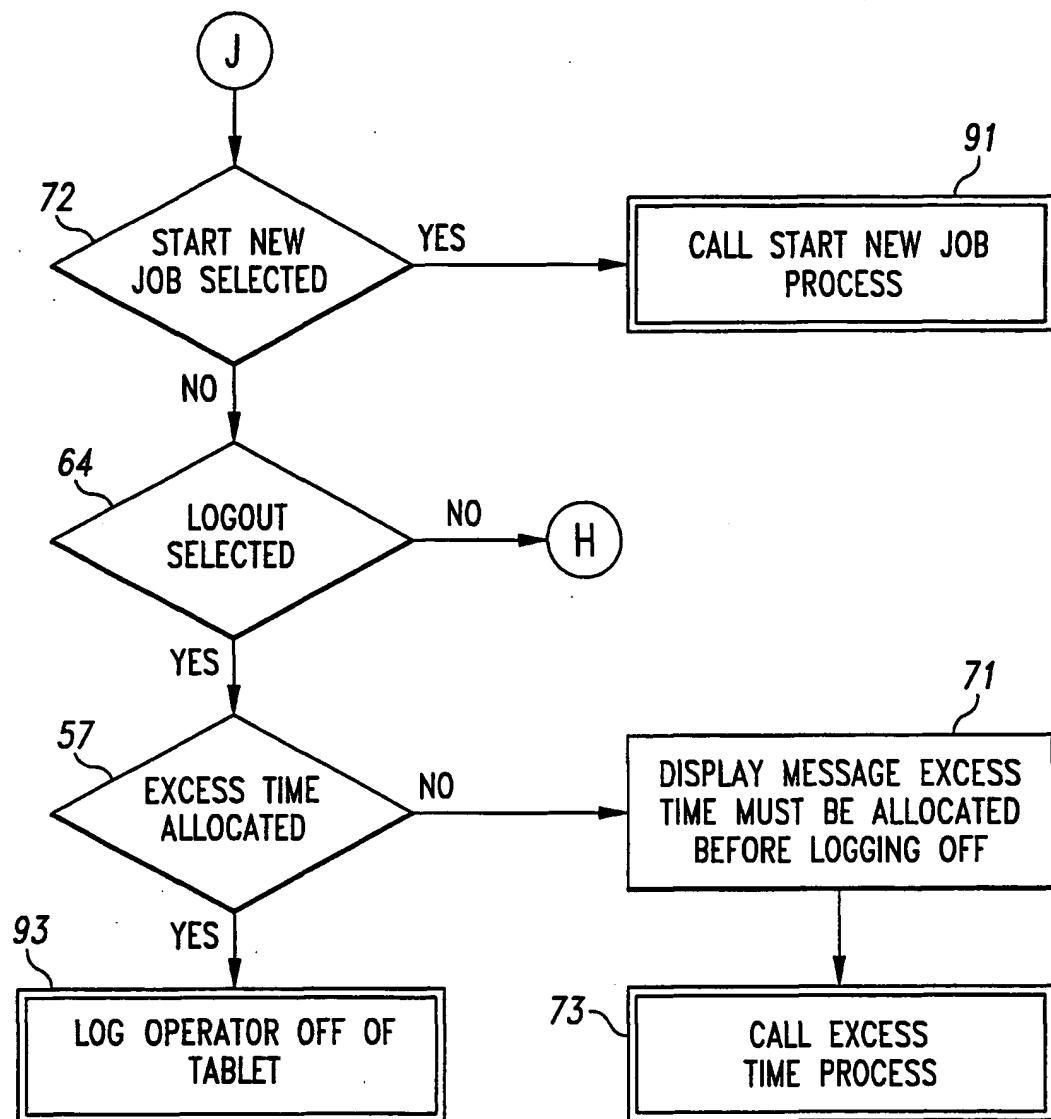


Fig. 3B

5/49

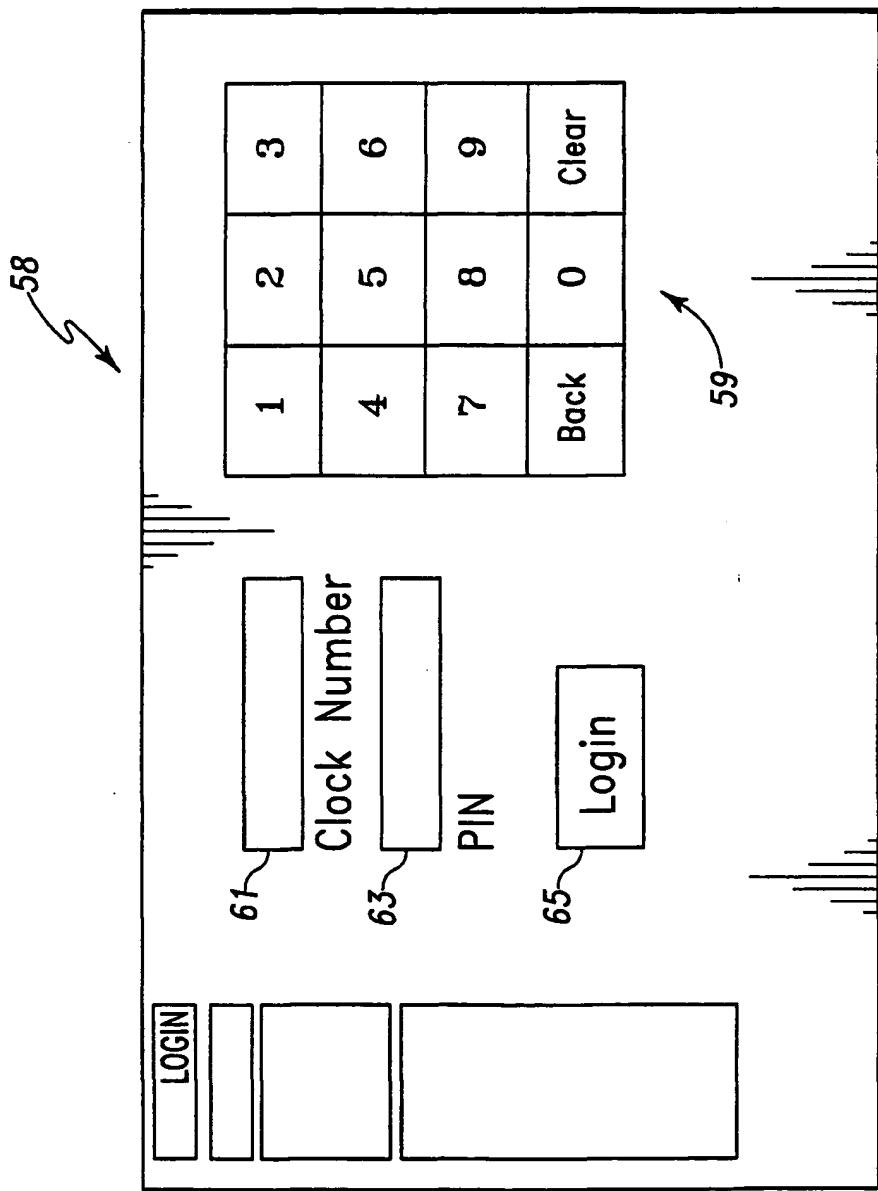


Fig. 4

6/49

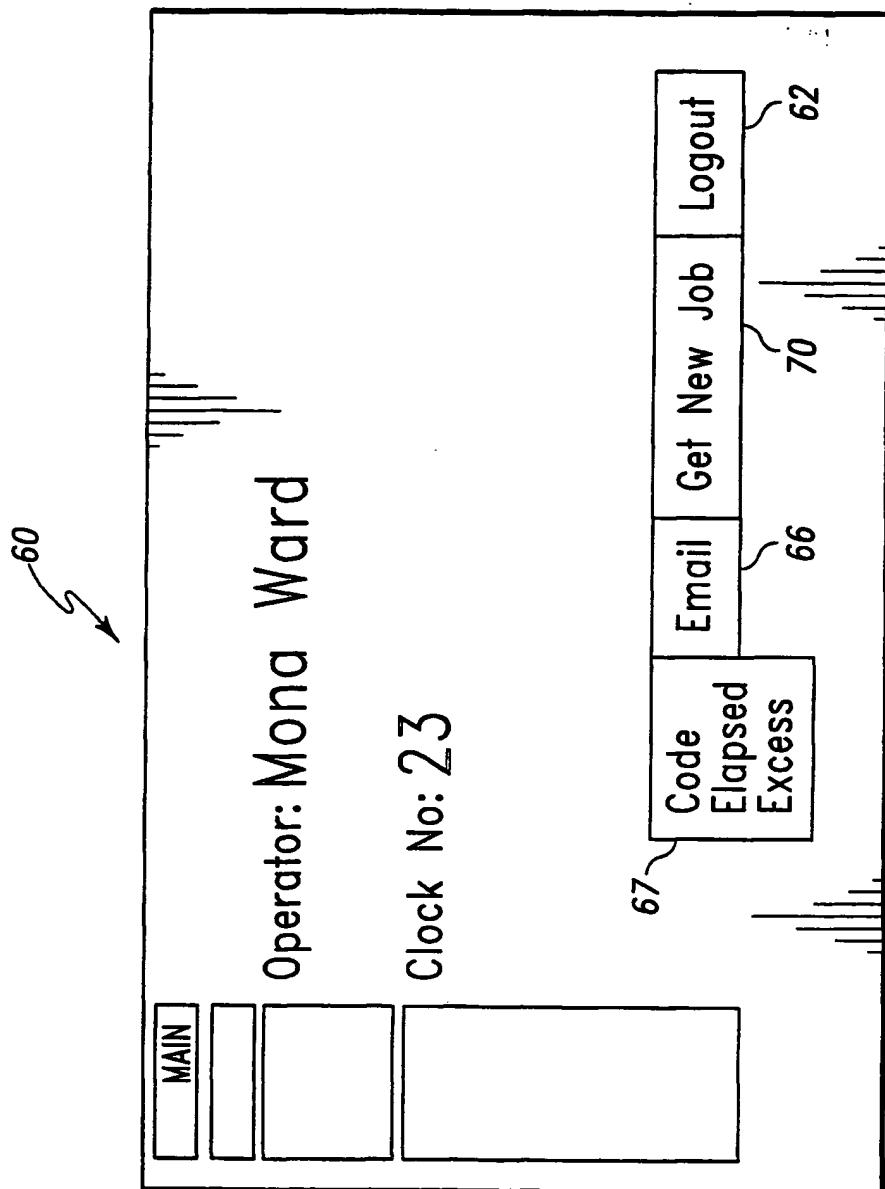


Fig. 5

7/49

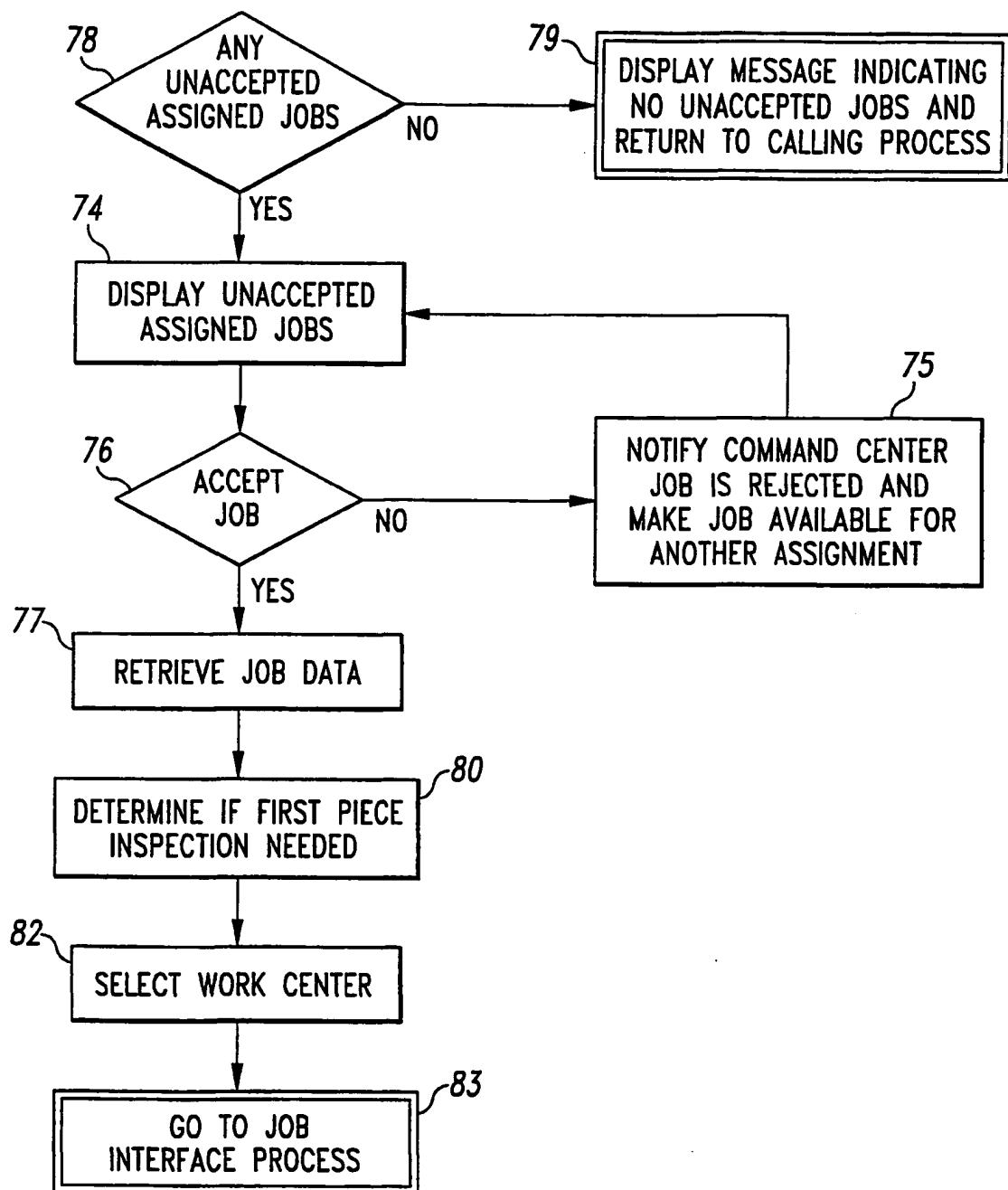


Fig. 6

8/49

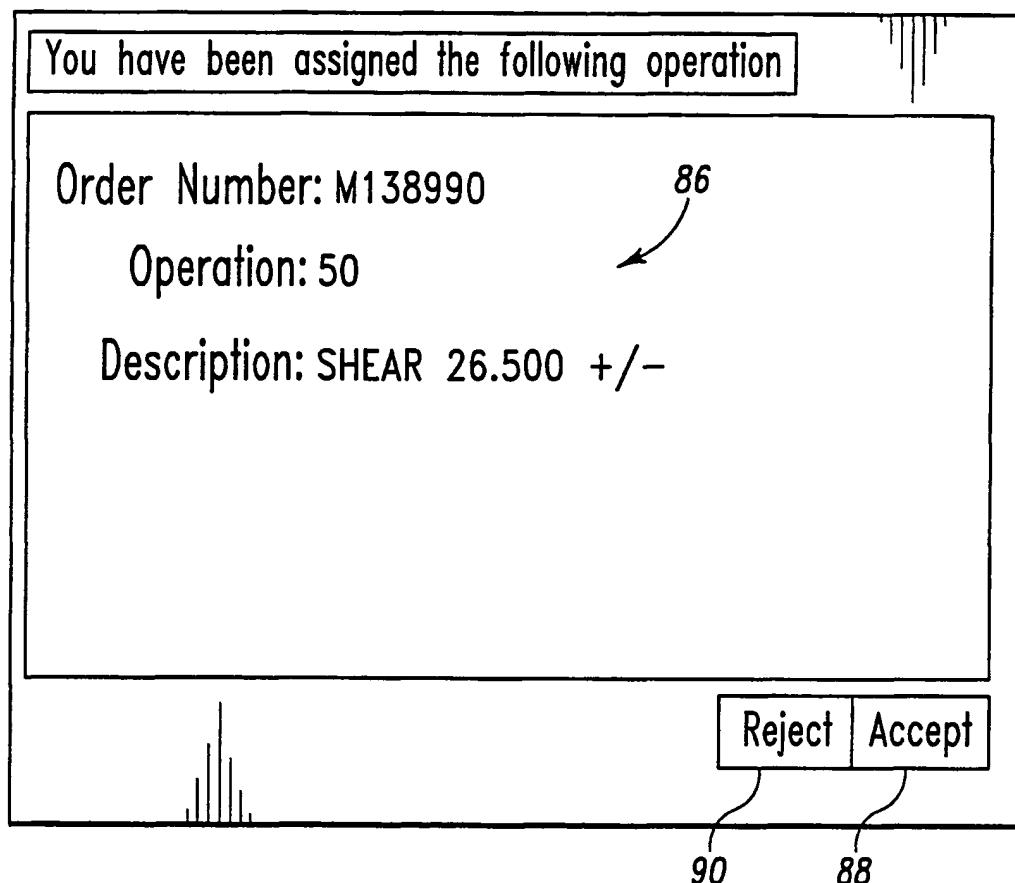


Fig. 7

9/49

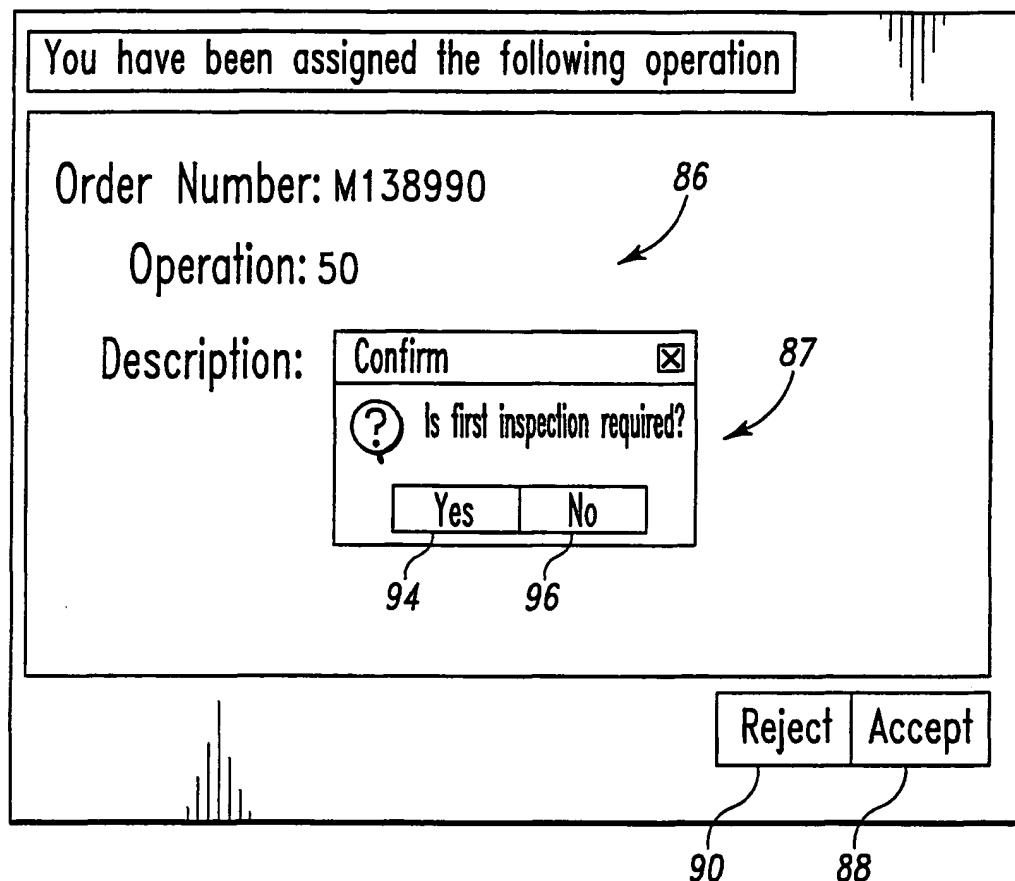


Fig. 8

10/49

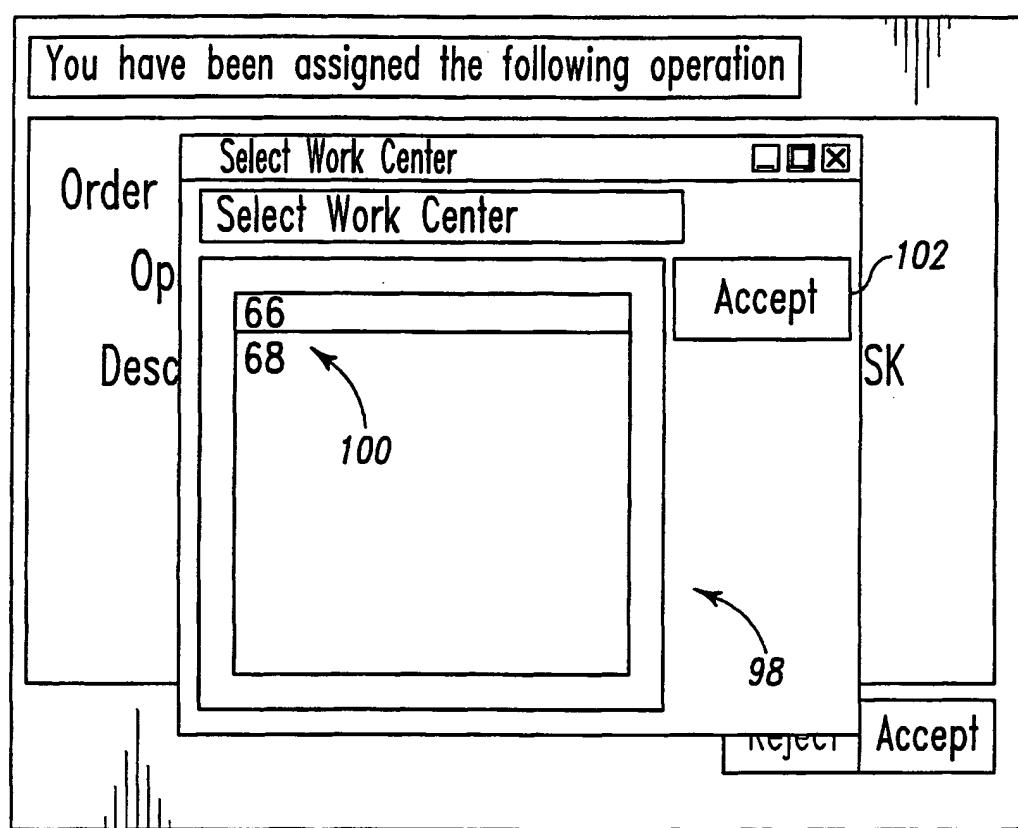


Fig. 9

11/49

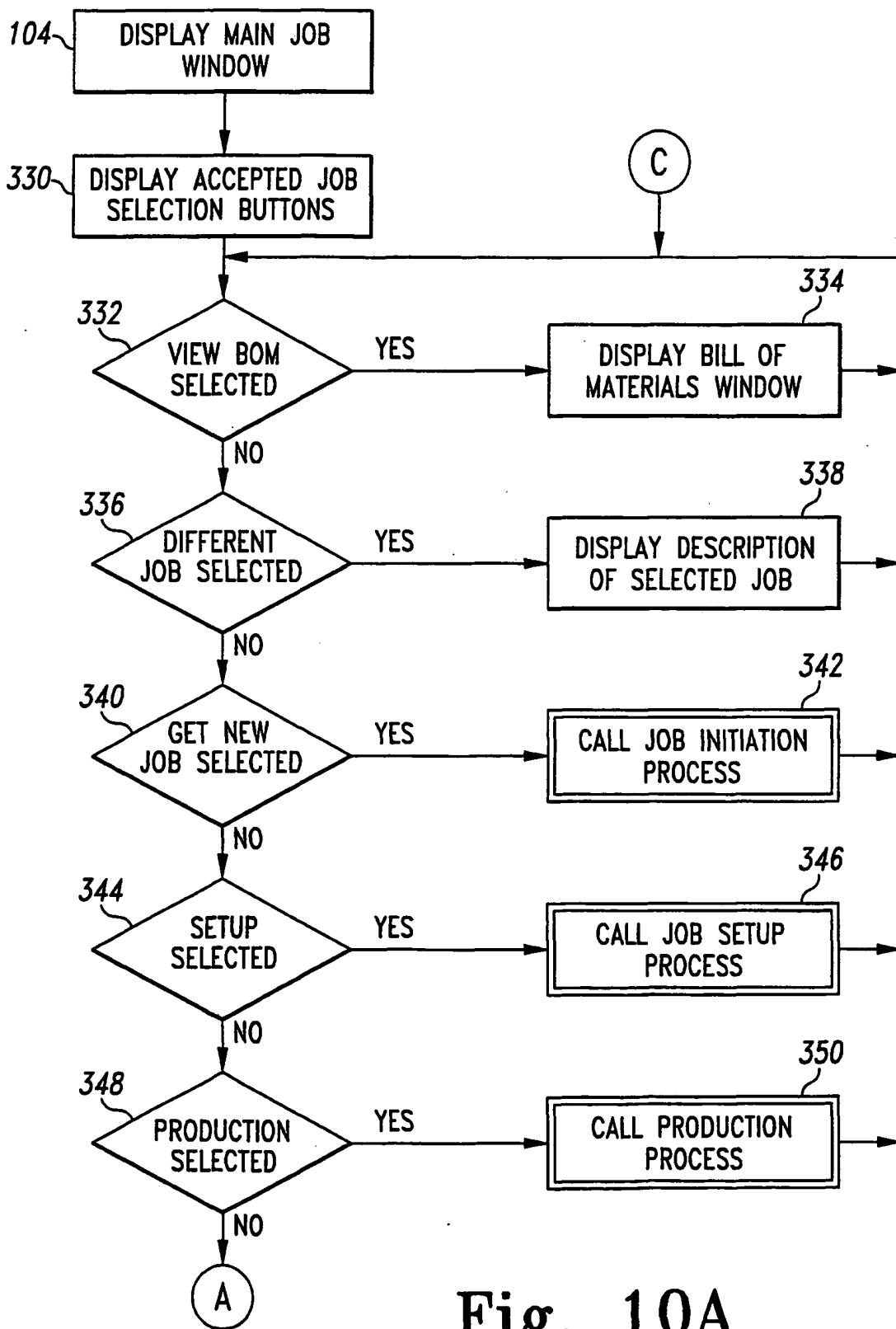


Fig. 10A

12/49

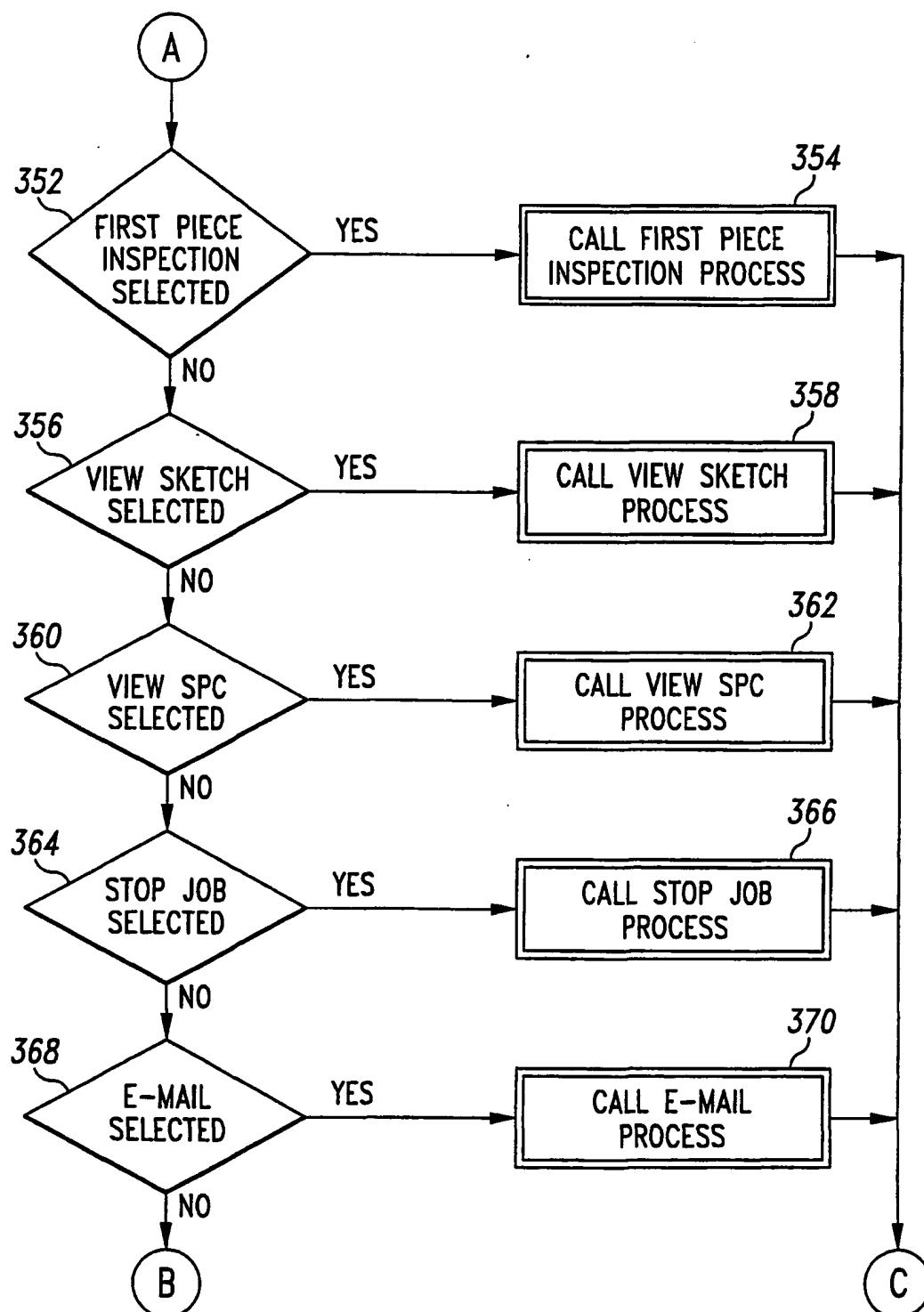


Fig. 10B

13/49

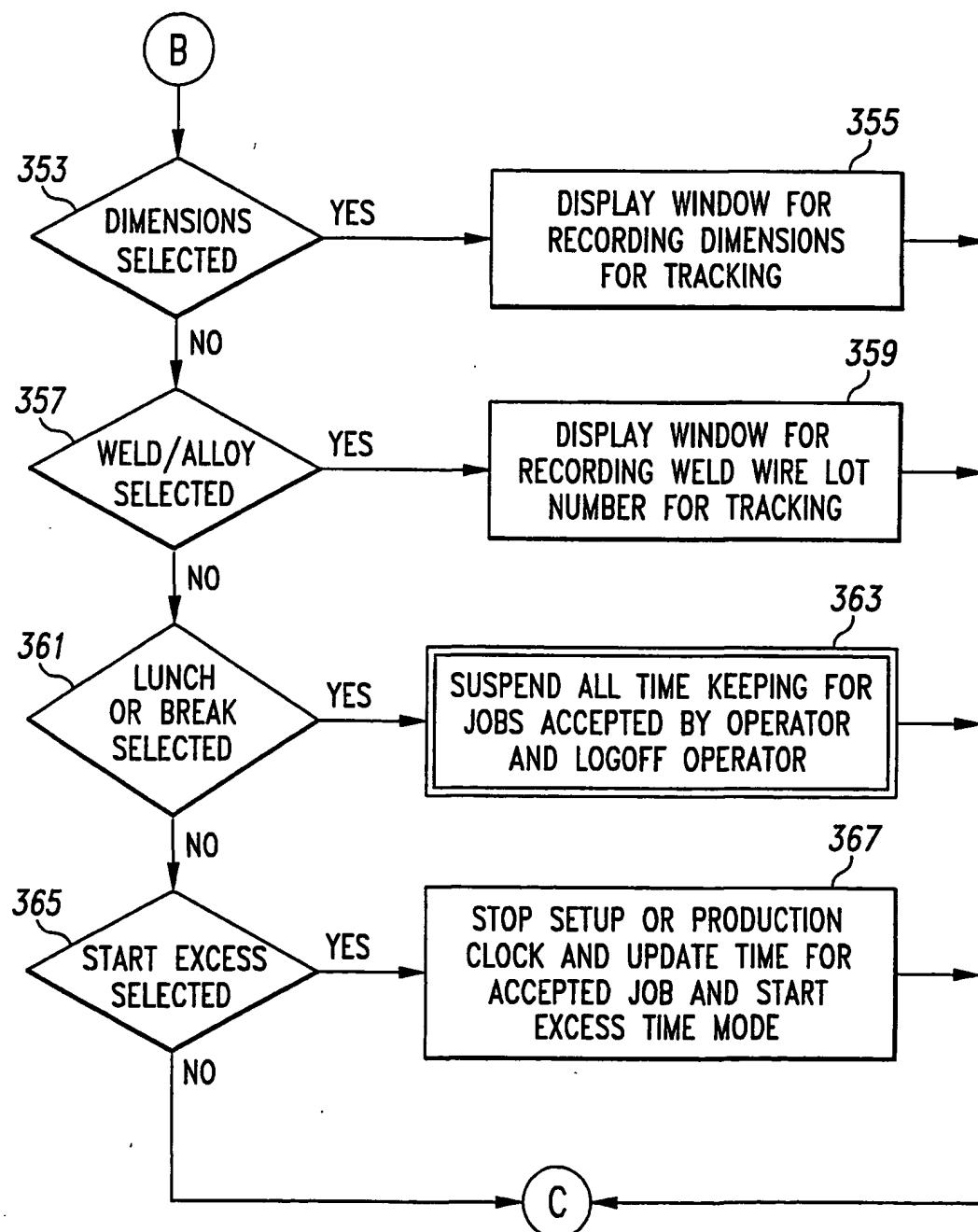


Fig. 10C

14/49

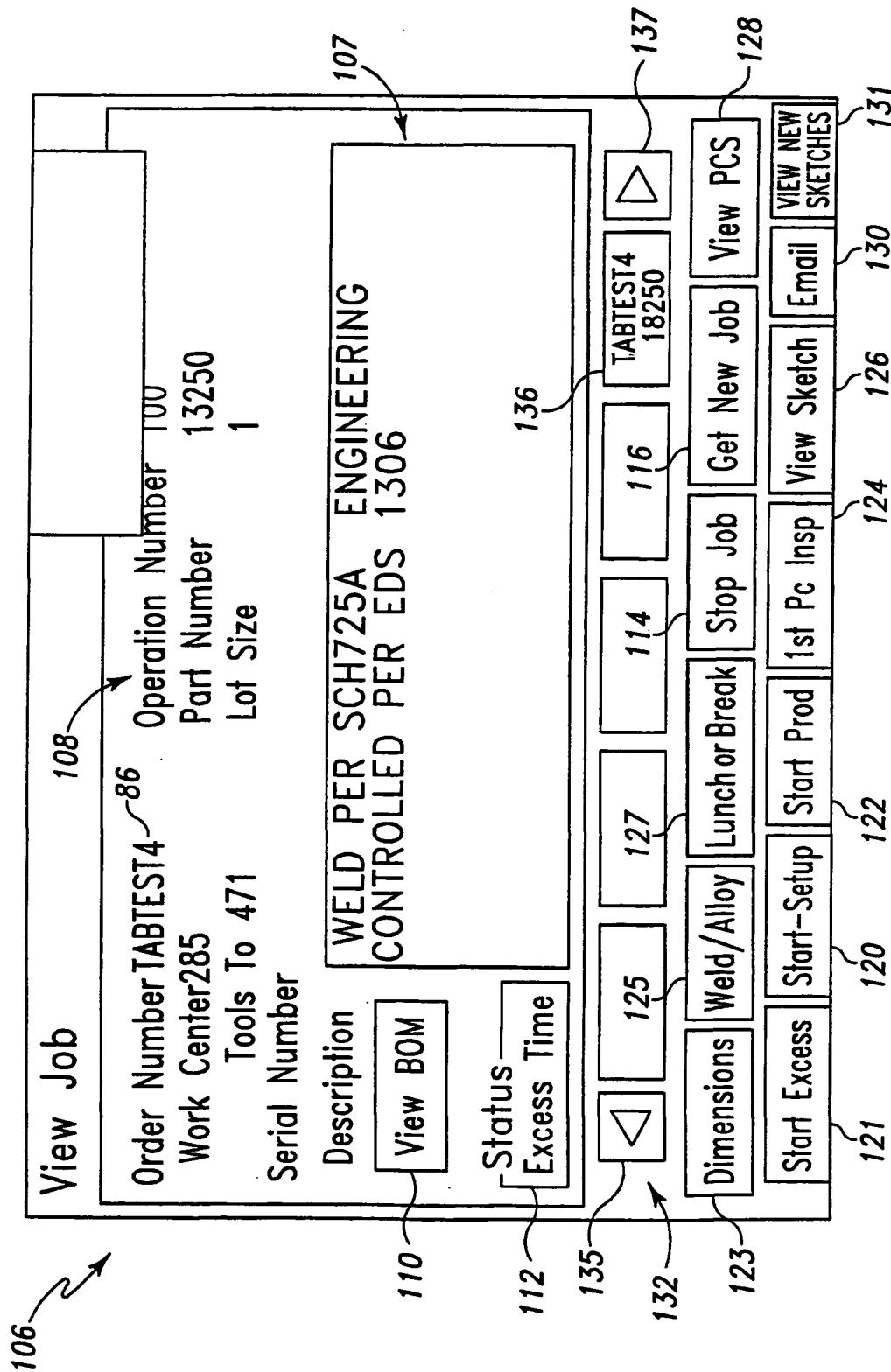


Fig. 11

15/49

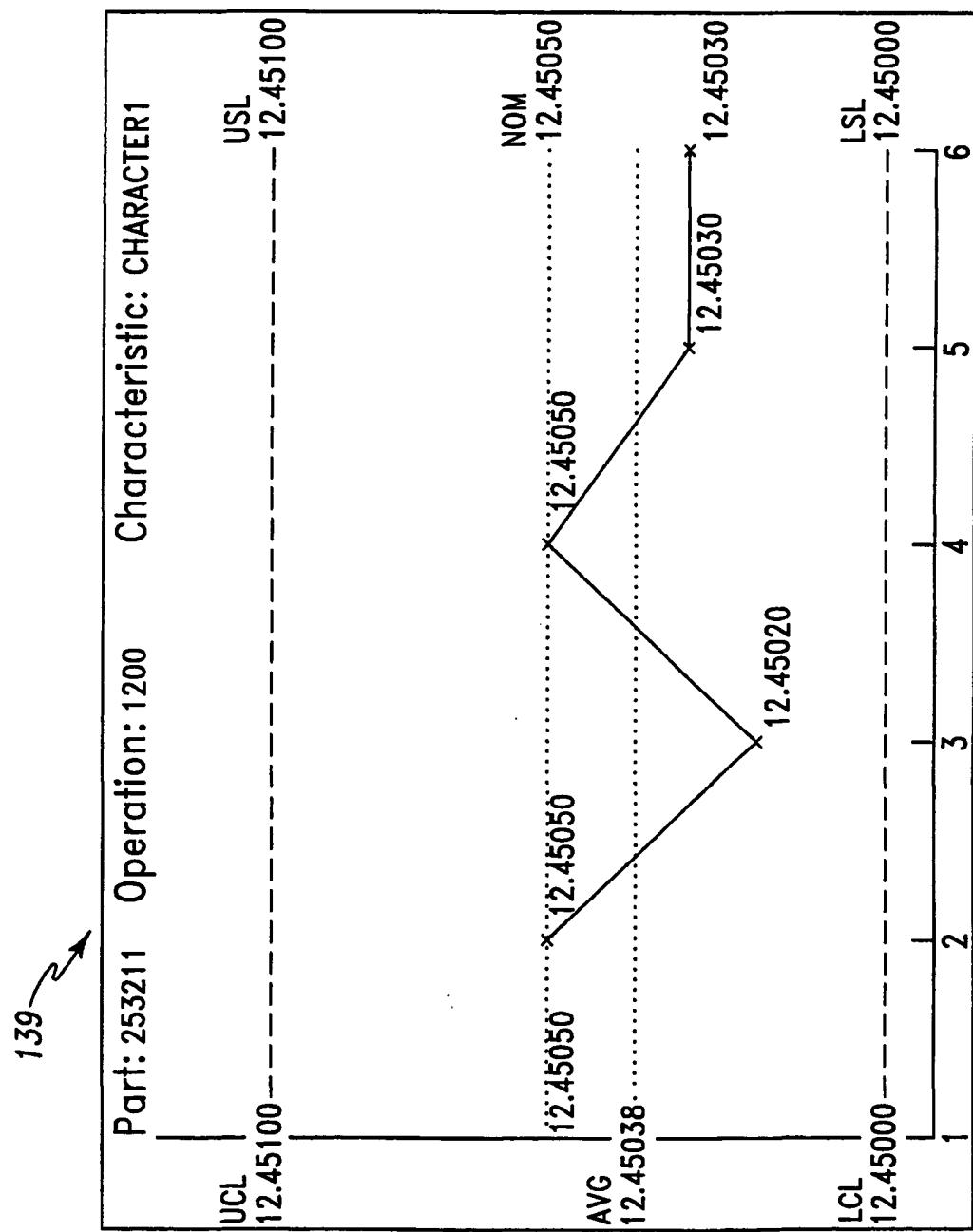


Fig. 12

16/49

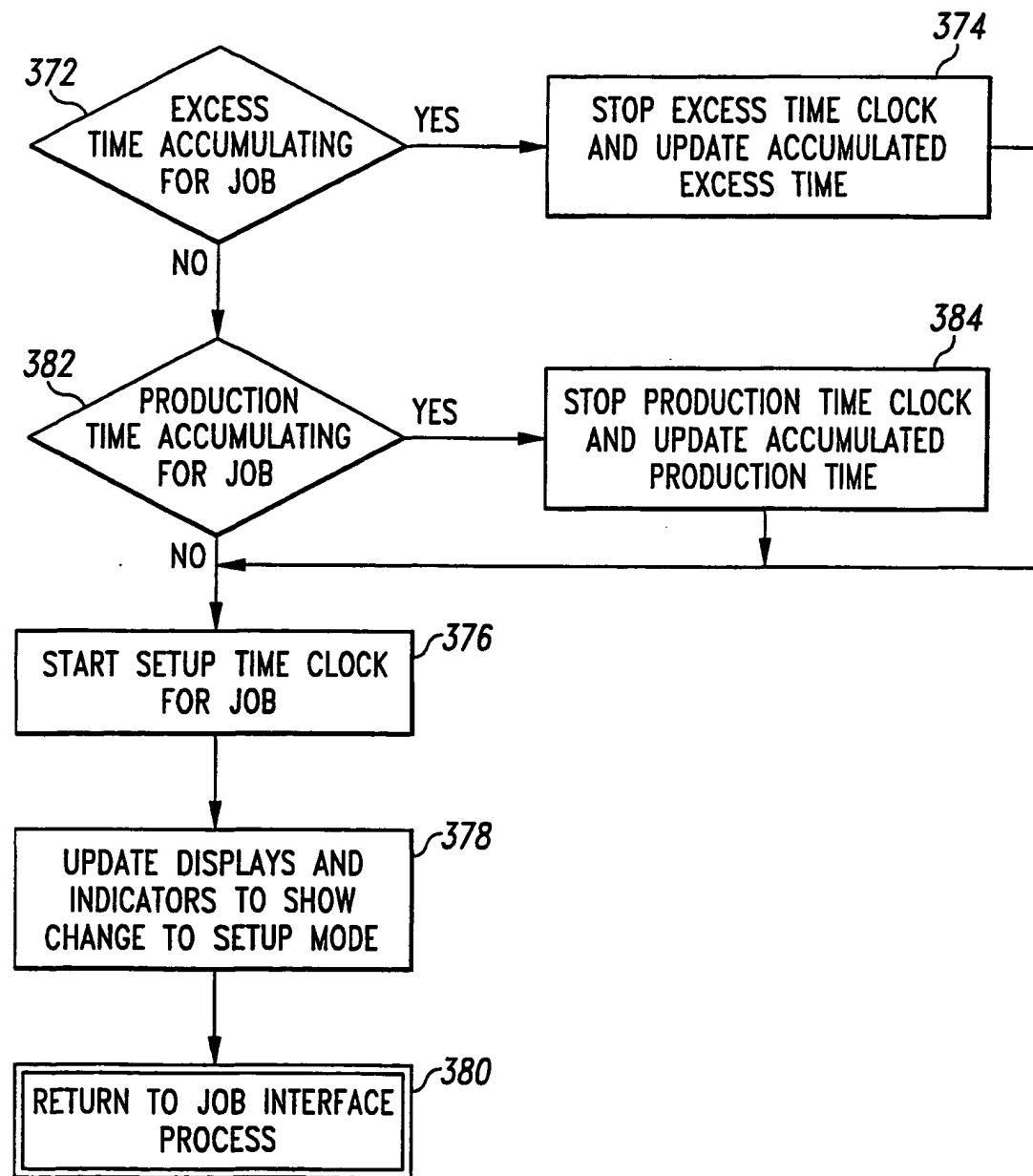


Fig. 13

17/49

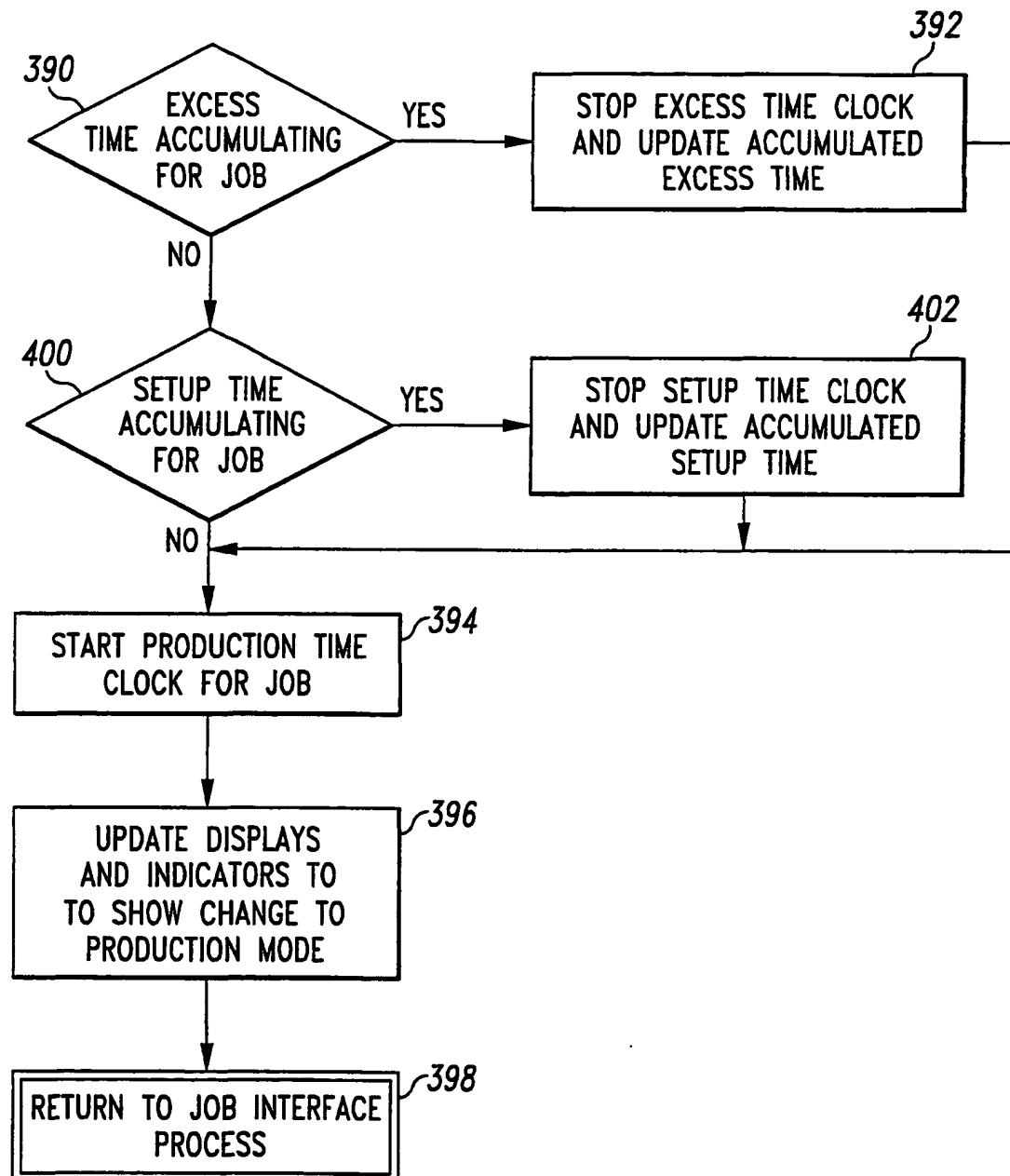


Fig. 14

18/49

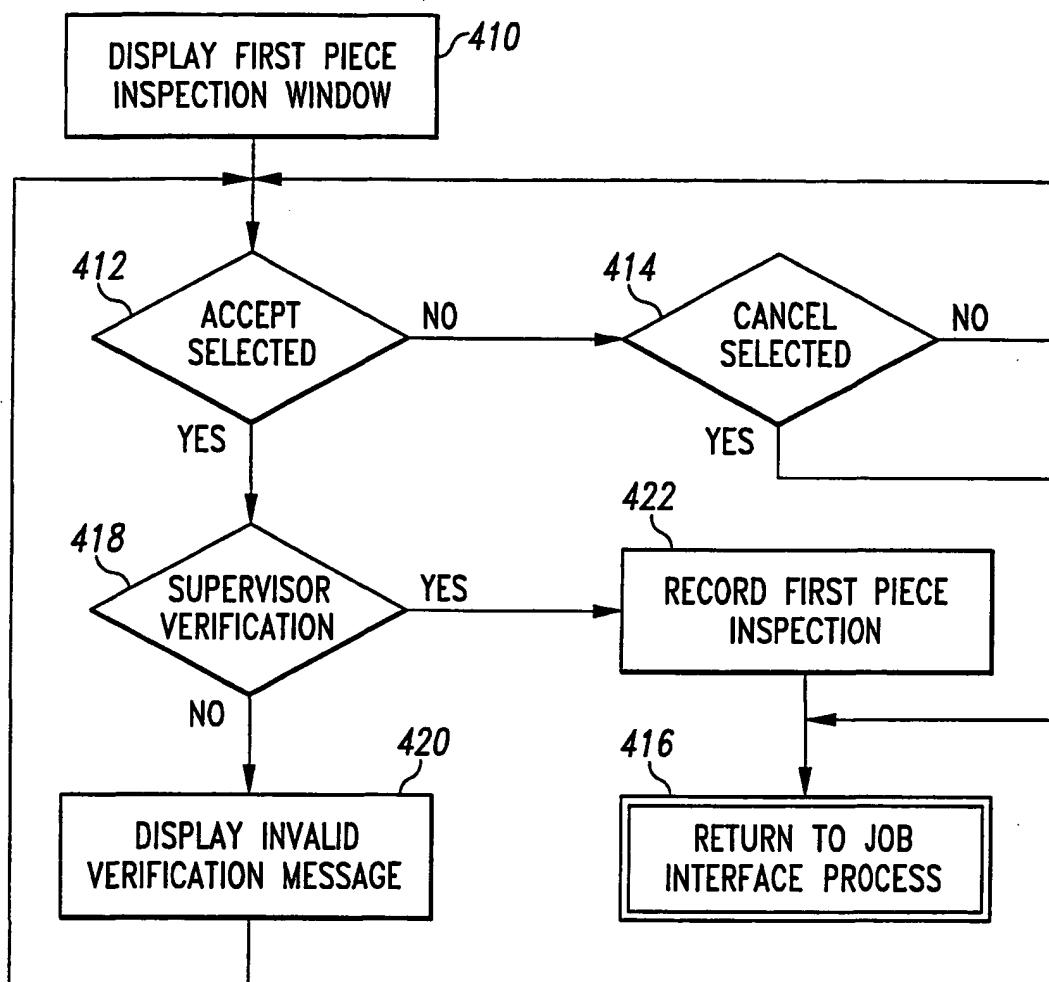


Fig. 15

19/49

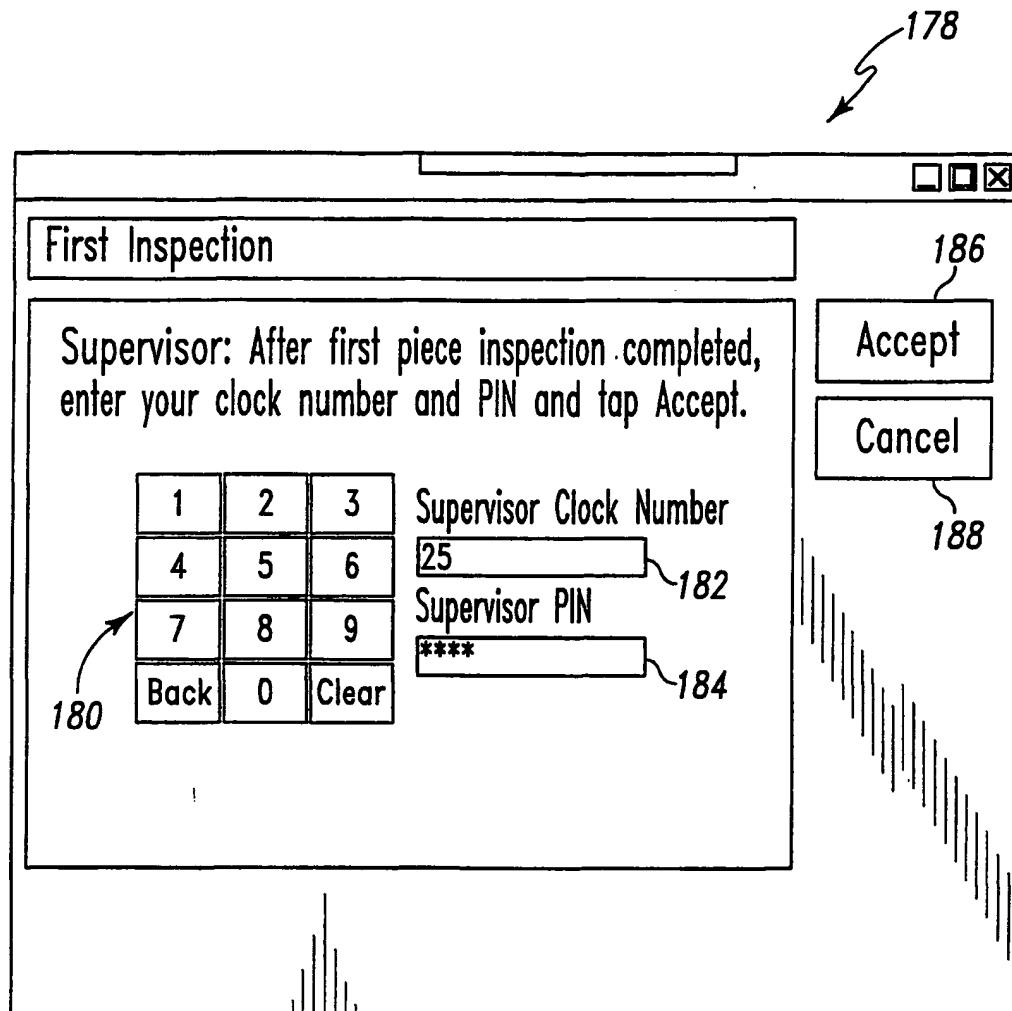


Fig. 16

20/49

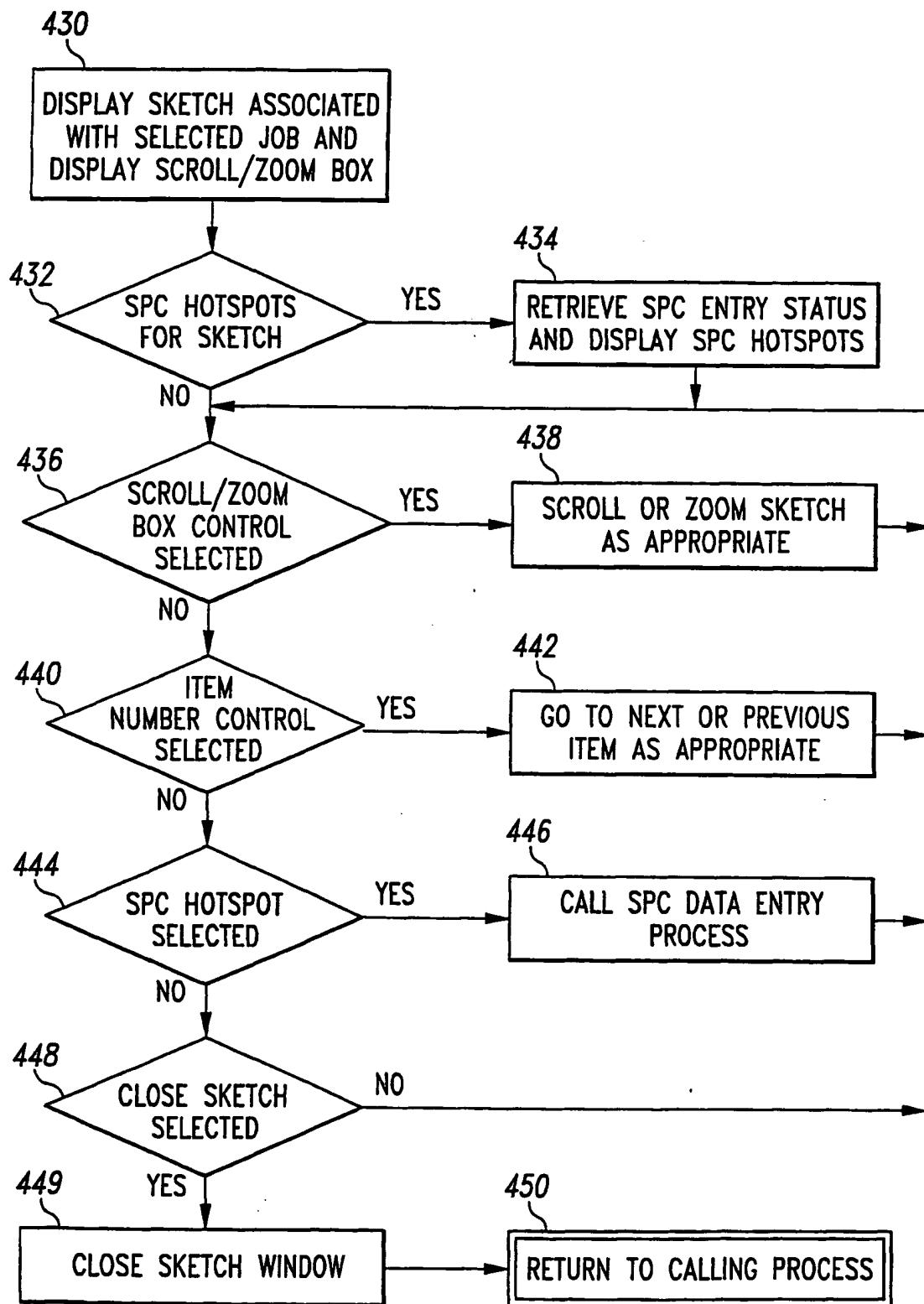


Fig. 17

21/49

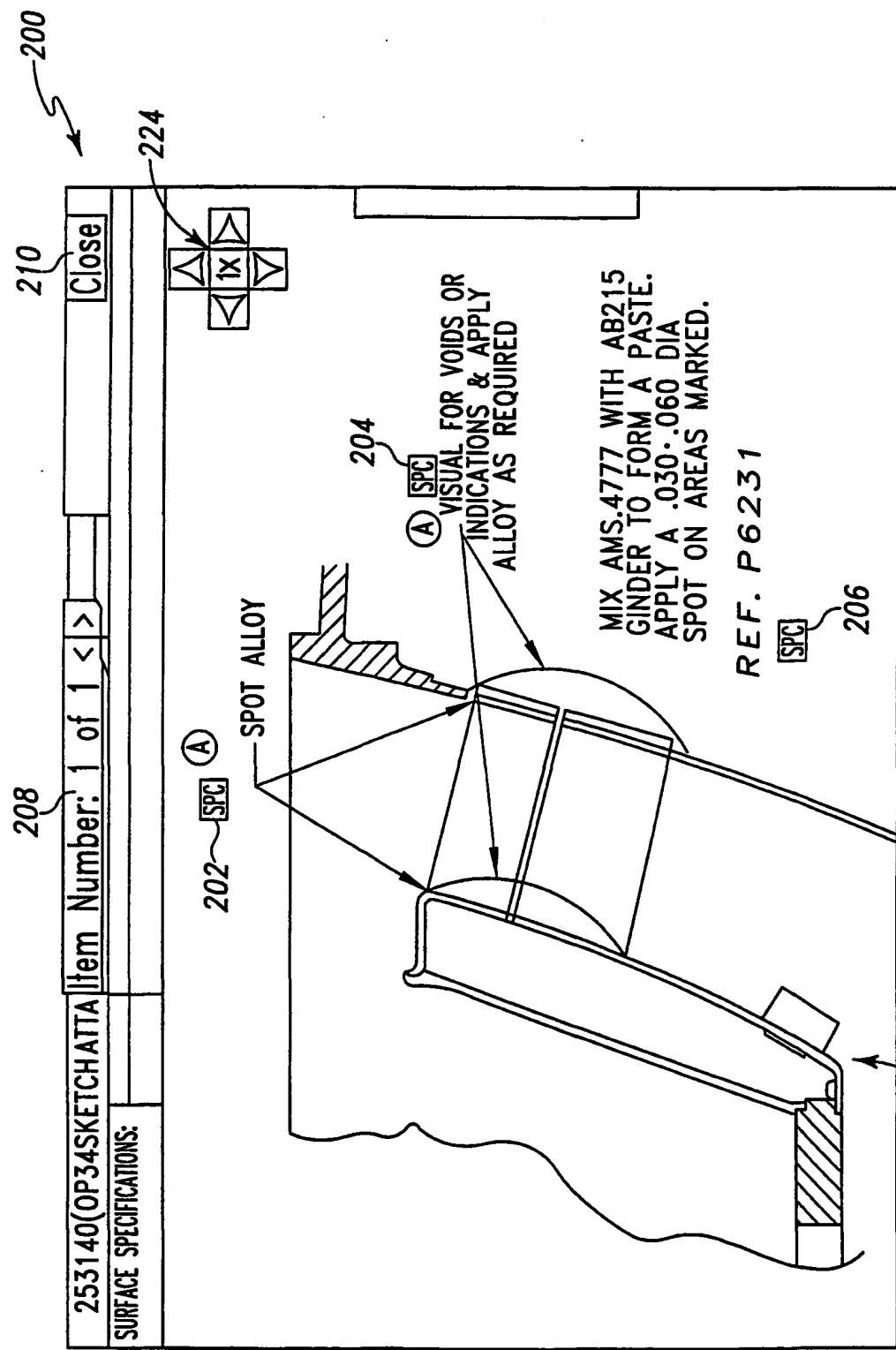


Fig. 18

22/49

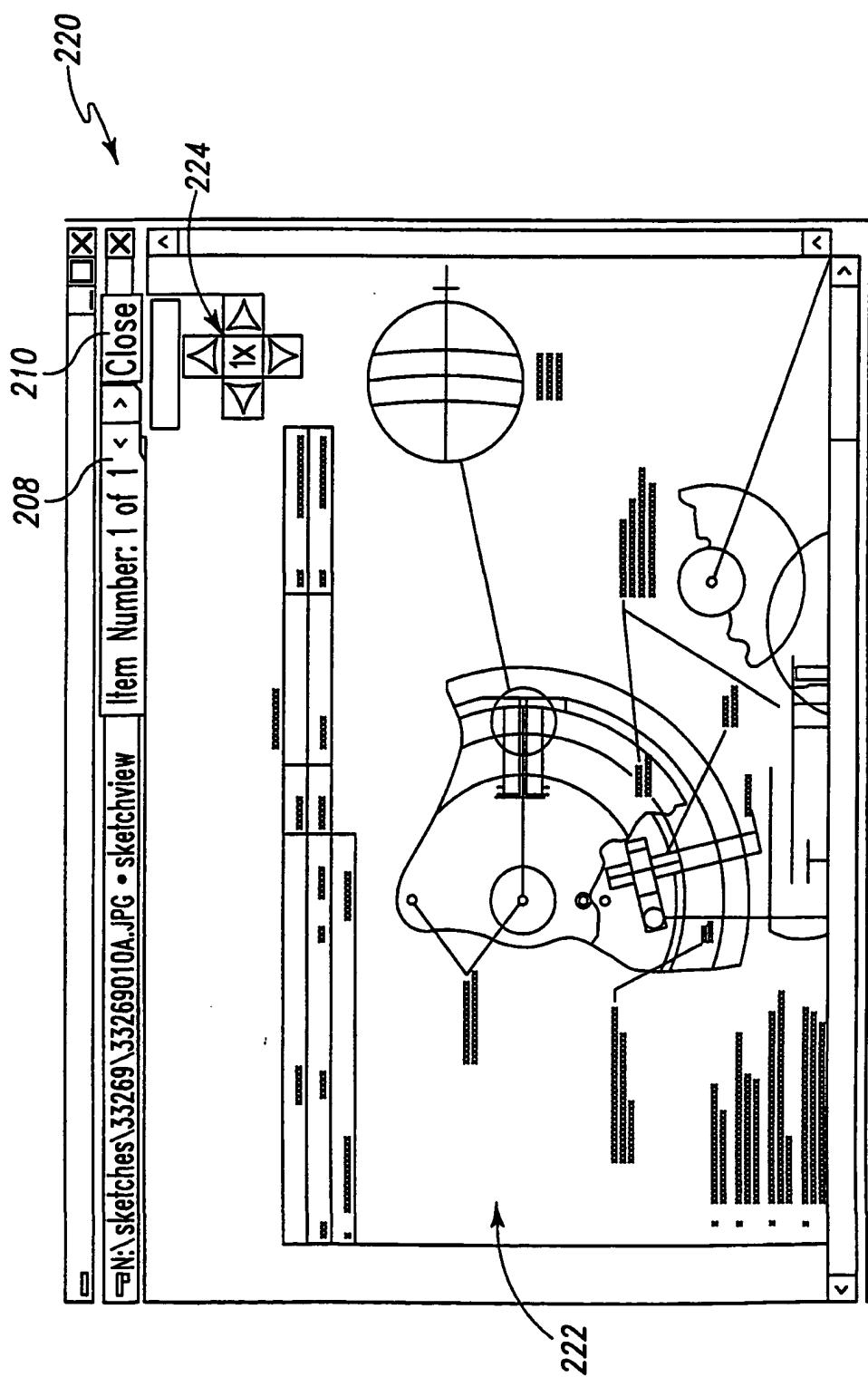


Fig. 19

23/49

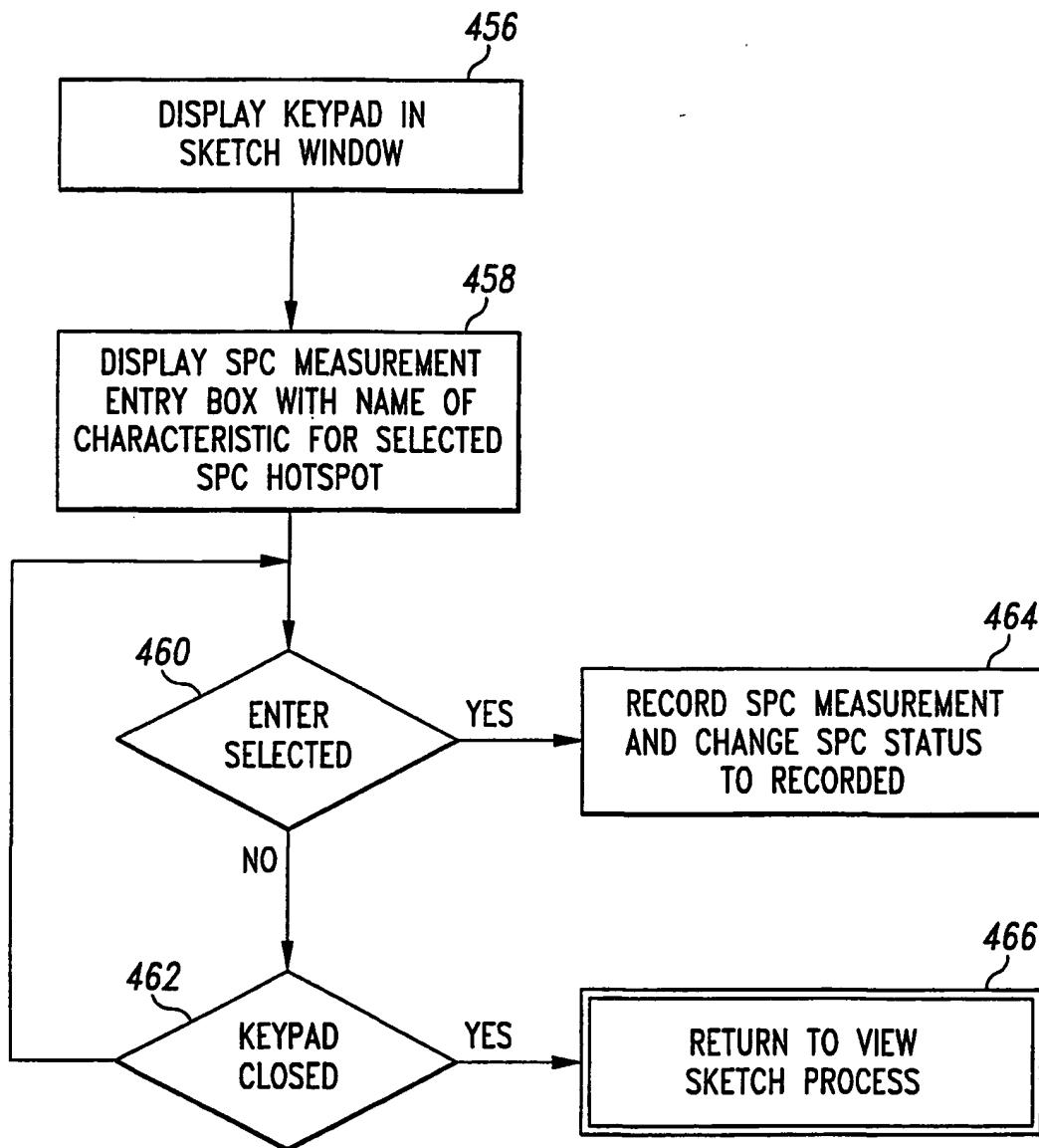


Fig. 20

24/49

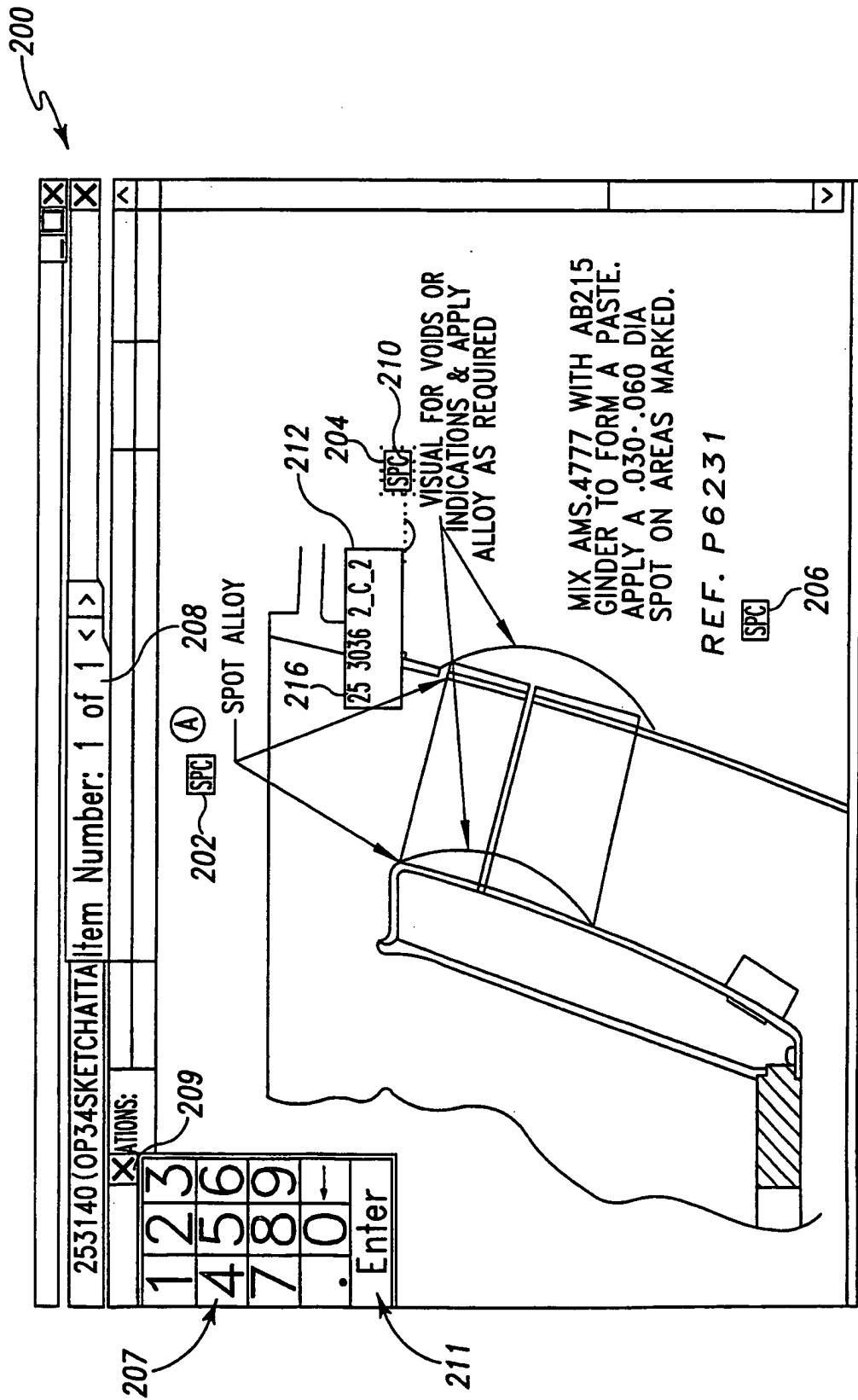


Fig. 21

25/49

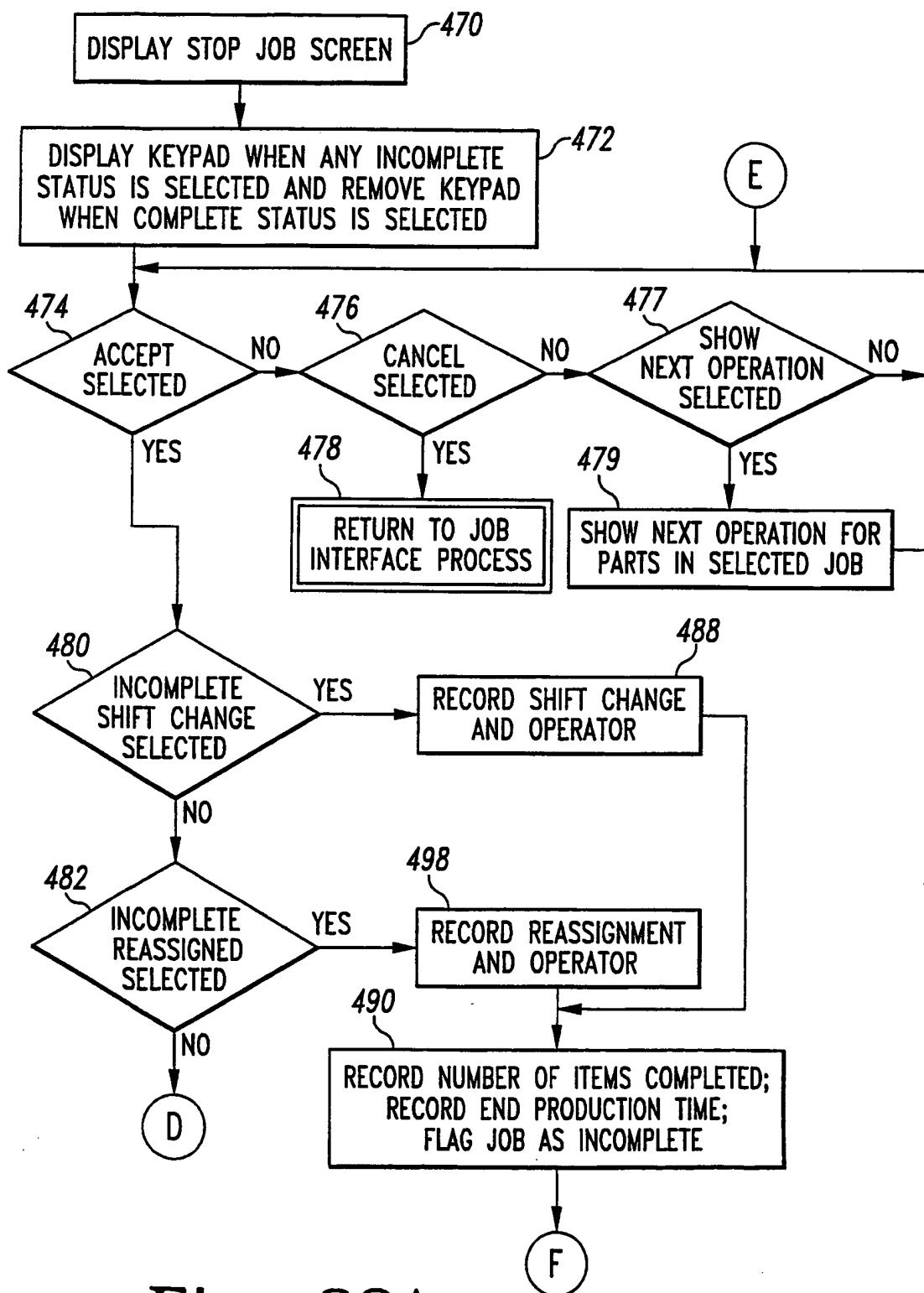


Fig. 22A

26/49

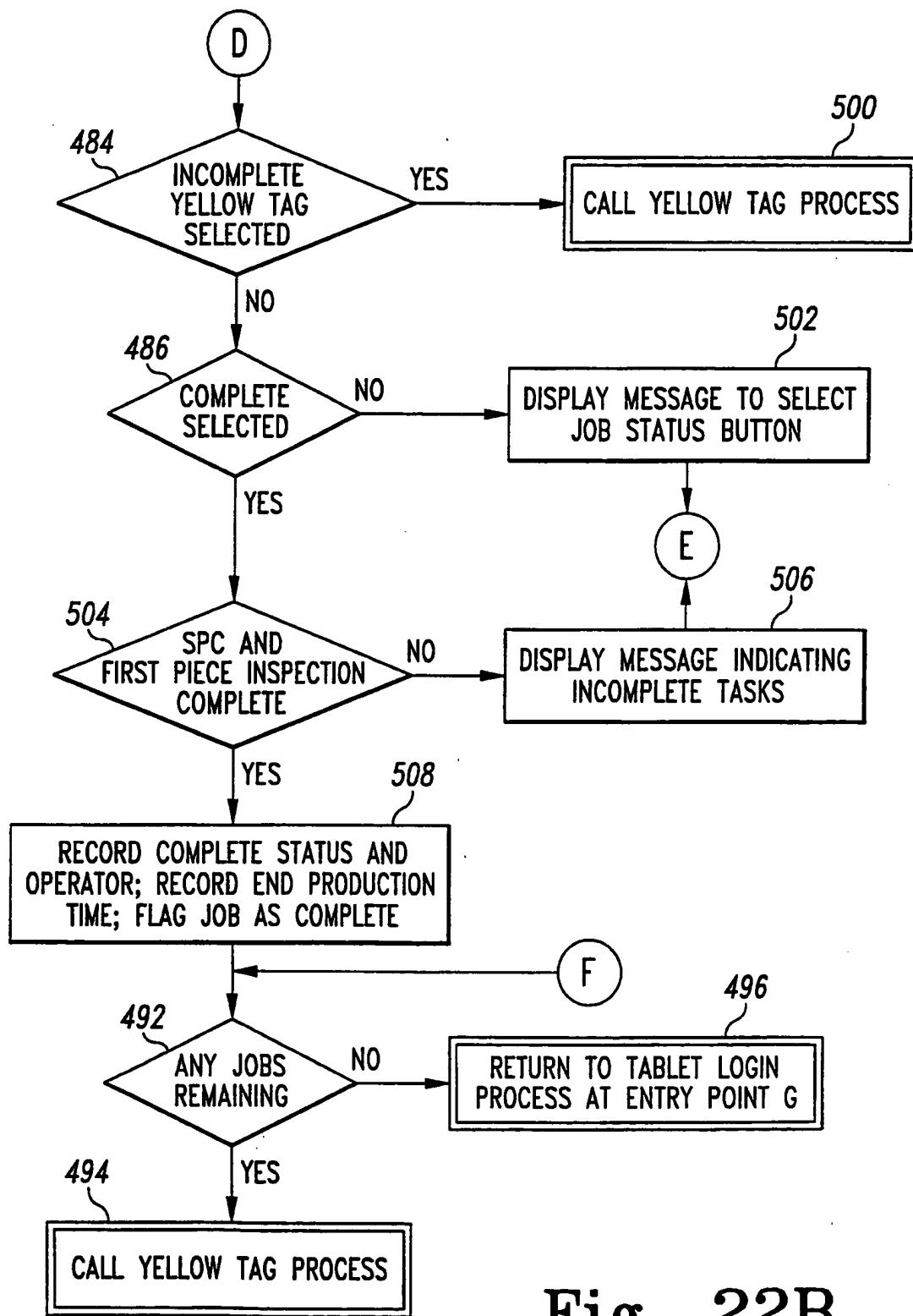


Fig. 22B

27/49

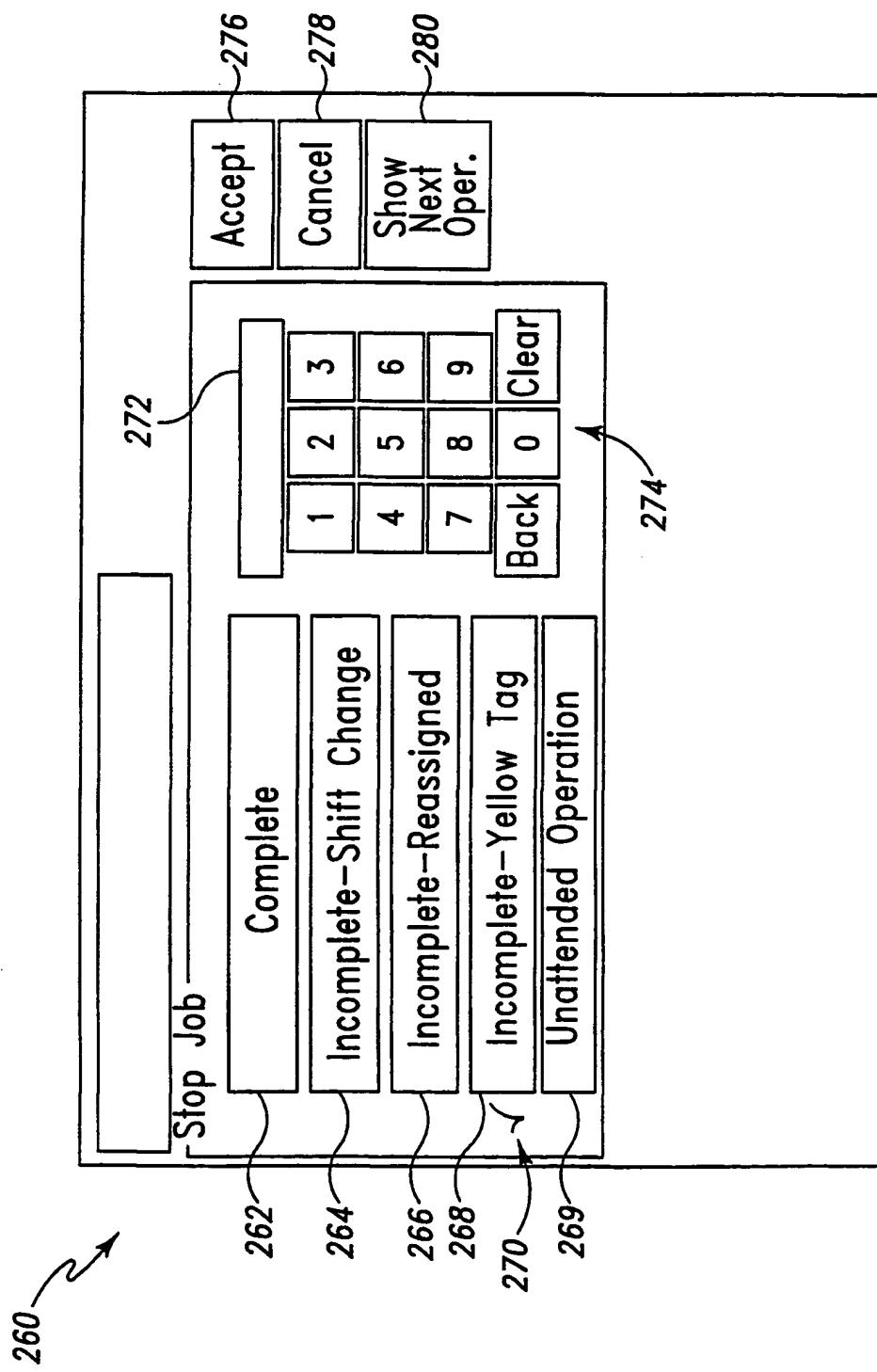


Fig. 23

28/49

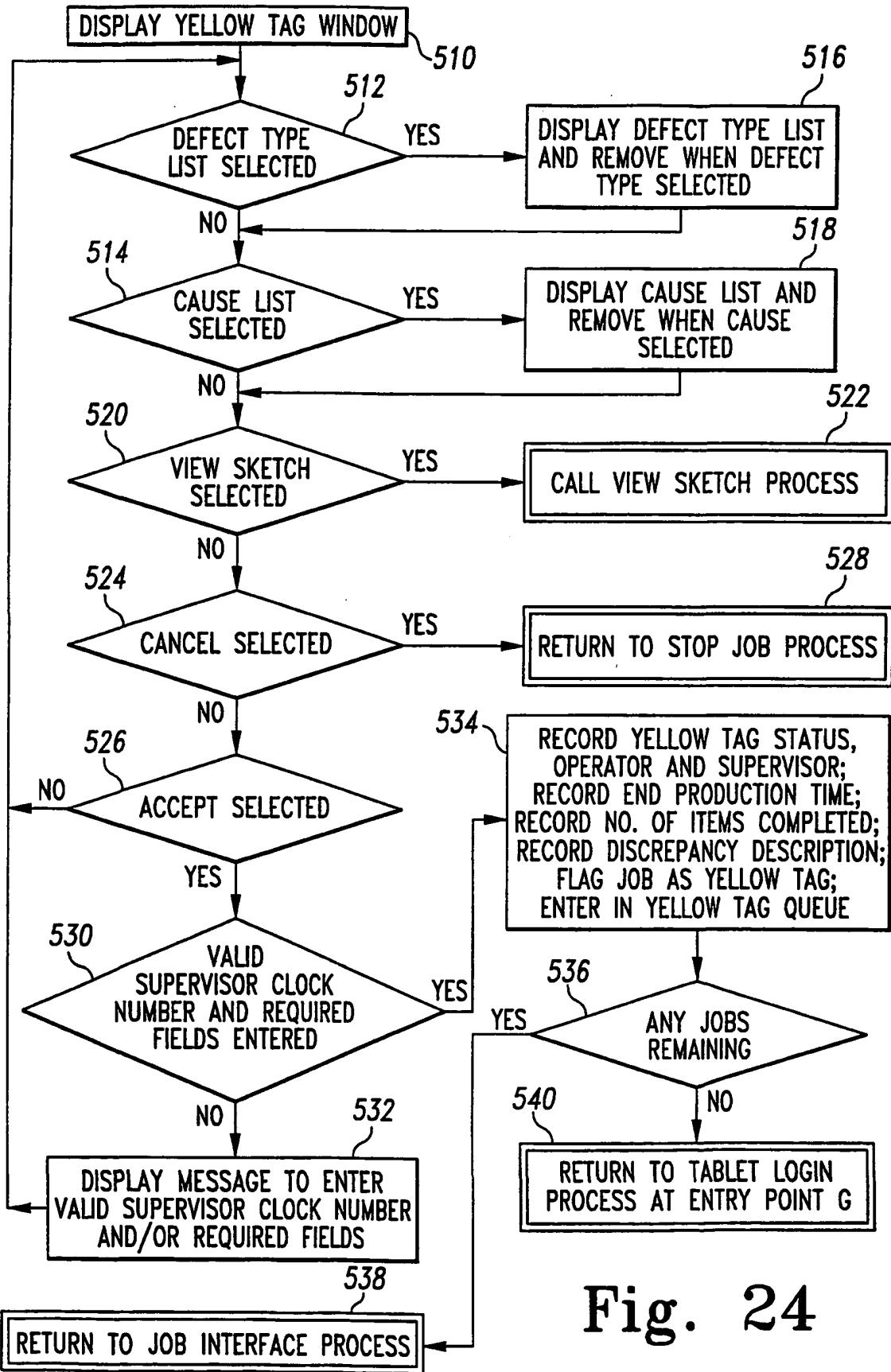


Fig. 24

29/49

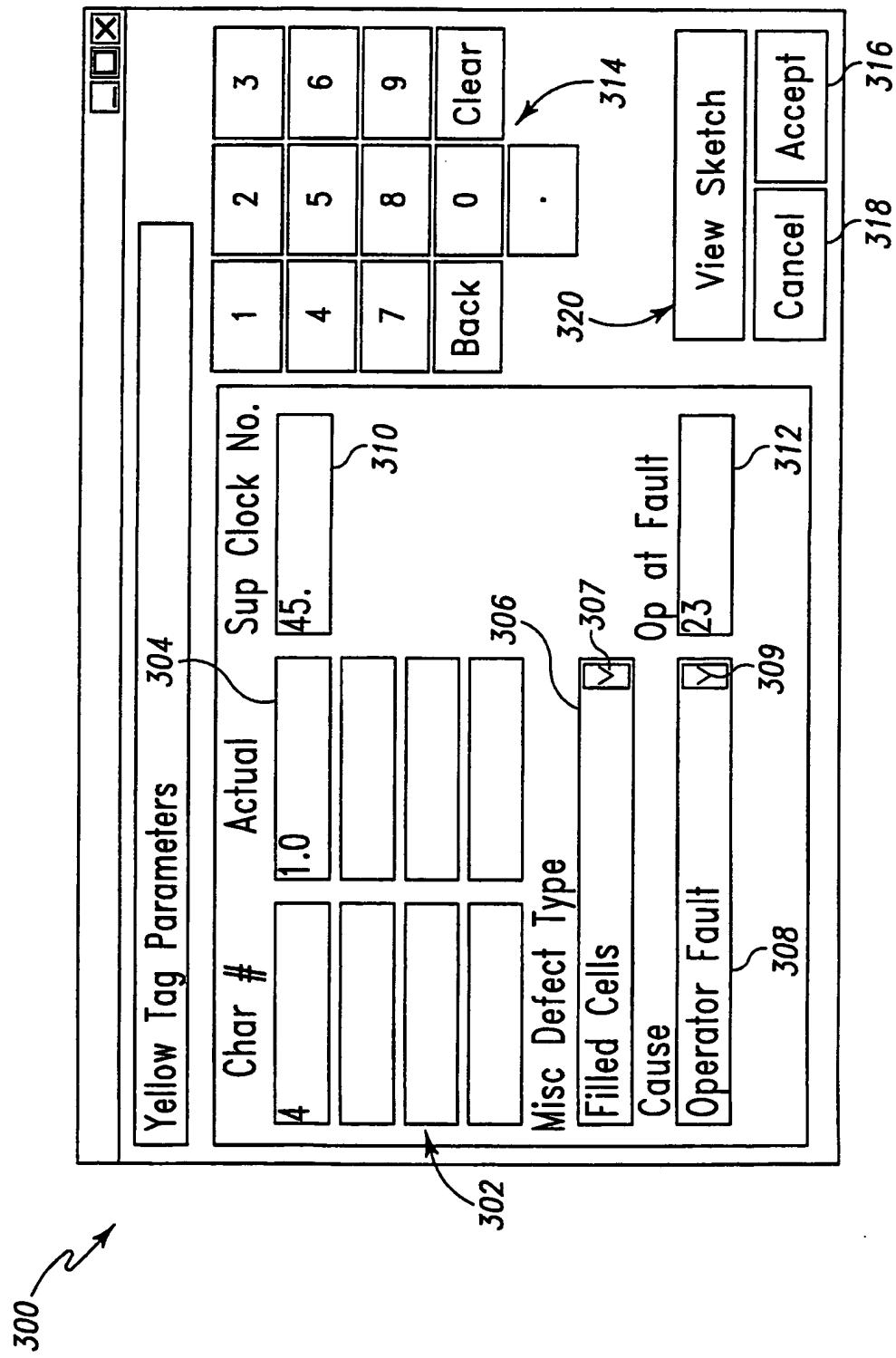


Fig. 25

30/49

320  
↓

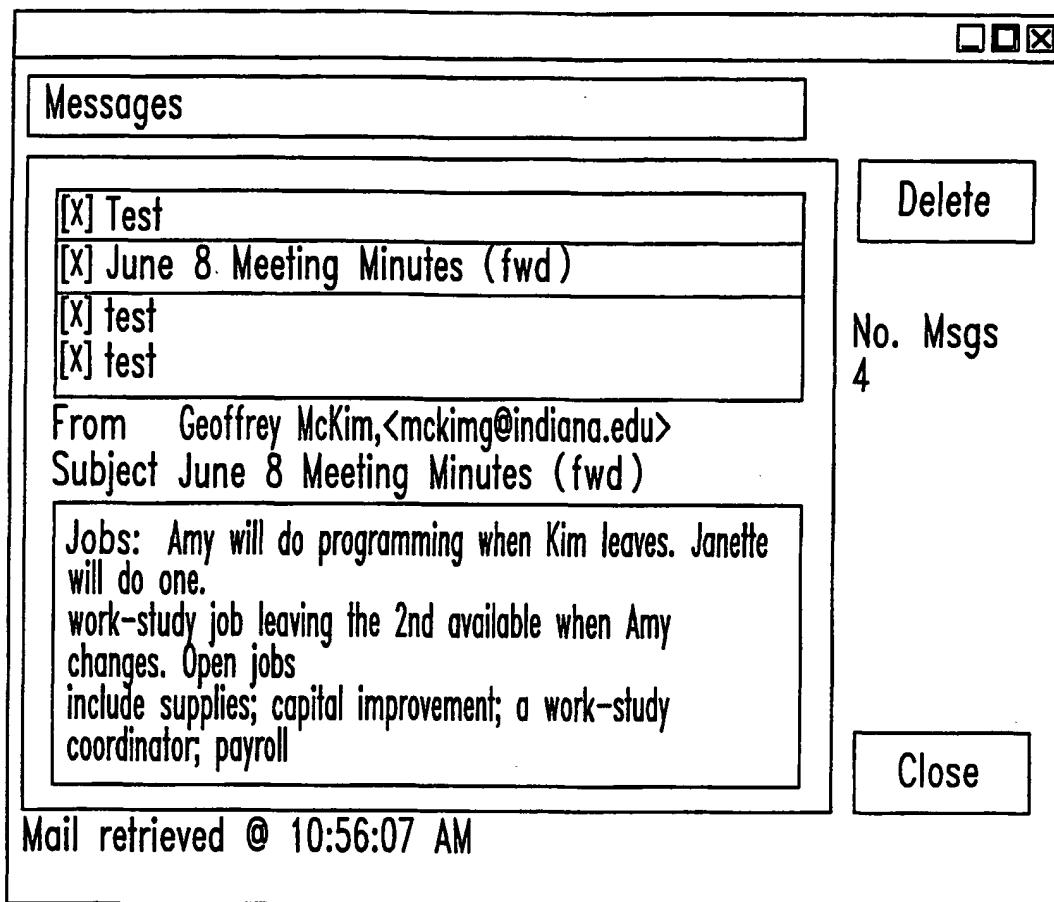


Fig. 26

31/49

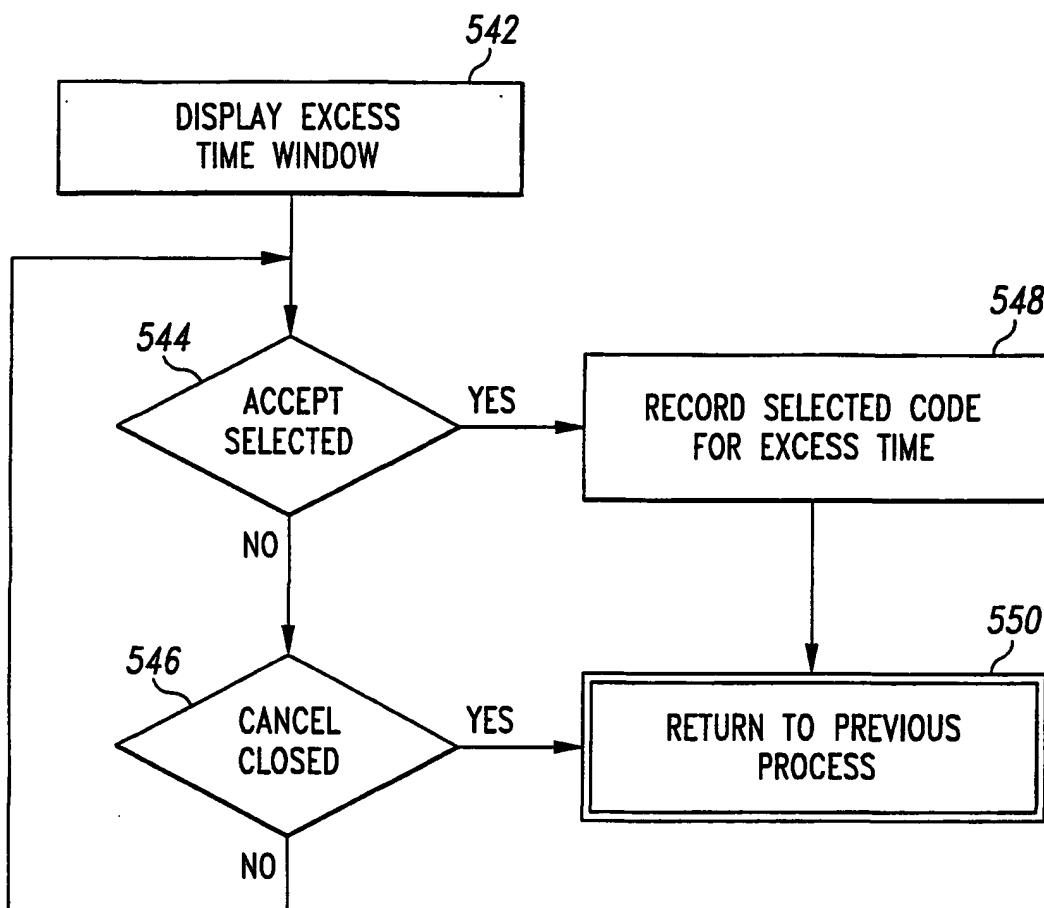


Fig. 27

32/49

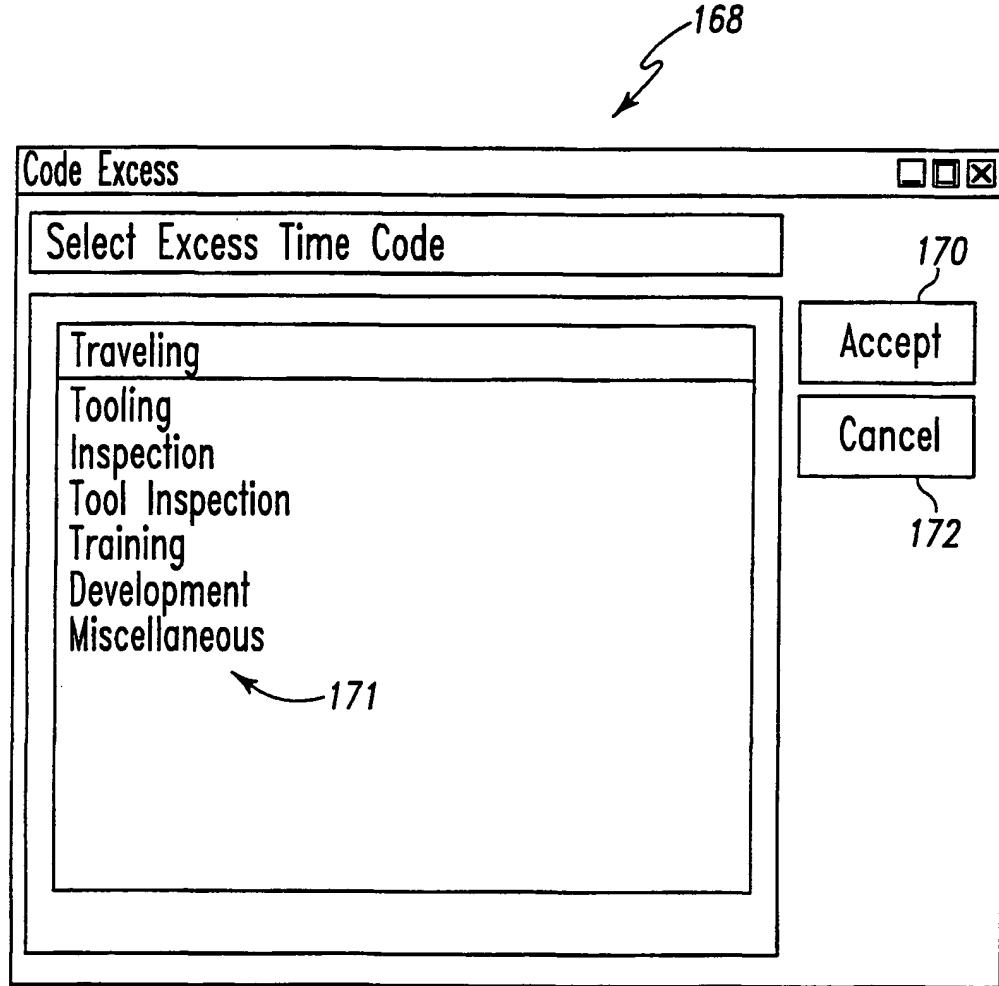


Fig. 28

33/49

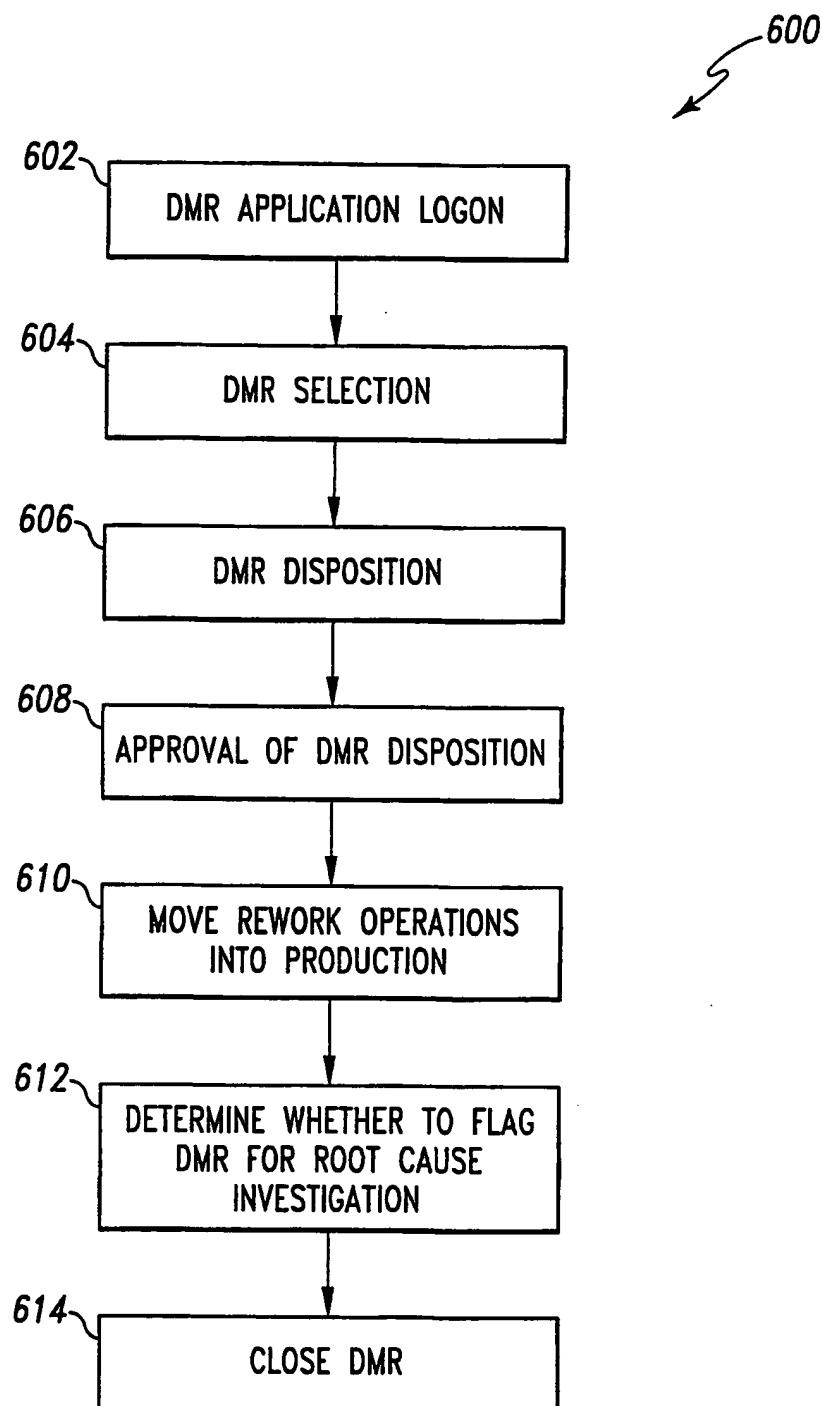


Fig. 29

34/49

620

Select Submitted DMR						
DMR ID	Date Created	Since Creation	Part No	Undisp	QE Apprvd	User
> 9678	10/13/1999 2:51:55 PM	1.72	25 348	1	<input type="checkbox"/>	
> 9859	10/14/1999 11:29:50 AM	0.86	25 240	0	<input type="checkbox"/>	

622

Current Logon Info  
 Username: chrisd  
 User Type: Quality Engineer

Legend  
 Open DMR;  
 Rejected Disposition

624

626

Fig. 30

35 / 49

640

Edit Submitted DMR (christd logged in)	
Order Number	4738
Operation	18303
Part Number	205
Cause	38-2913
Defect	Weld
Work Center	410
Description Summary	
Undisposed Use As Is	Rework
0	0
MRB	Scrap
0	0
RTV	
0	0

642

Otherwise OK Yes

Serial Num Tag 6849

Sample Size 1

Lot Size 1

Quantity Rejected 1

Discrepancy desc crack in butt weld on •13 as marked

644

646

648

Date	From	To	Items Order No	ME App	Comments	Rejection Com
>8/31/1999 7:35:56 AM	Undisposed Rework		1M183030	Yes	No	
			658	659		
						>
						<
			650	652	654	656 Delete
						Save
						Back to Main Menu

Fig. 31

36/49

660

672

674

662

664

666

668

670

Add Disposition (me logged in)

Add Disposition

Disposition From Rework

Disposition To Undisposed

No Transferred 1

Order ID 12334

Comment Part was flawed, 005mp X/1

Fig. 32

37 / 49

688

680

Rework Operations			
Operation (ROW) #	Op.	Sketches	Description
401	33 SMALL MACHINING CENTER	<input type="checkbox"/>	E.D.M. TO REMOVE BROKEN TAP
402	110 ACID CLEAN DUSTBLAST	<input type="checkbox"/>	DEGREASE
403	105 STEEL METAL	<input type="checkbox"/>	HAND TAP & CHECK THREADS
404	145 INSPECTION DM & VISUAL	<input type="checkbox"/>	INSPECT REWORK
500	25 MACHINE SHOP	<input type="checkbox"/>	DRILL PER SK50150B
600	105 SHEET METAL	<input type="checkbox"/>	DEBURR, EDGE BREAK.005-.010
700	125 MACHINE SHOP	<input type="checkbox"/>	BORE & CHAMFER PER SK 50170B. CHECK SPLT GAP DIM. & RECORD
1800	105 SHEET METAL	<input type="checkbox"/>	REMOVE NICKS & EXCESS BRAZE. SEE SK 201808 . THEN VAPOR DE
850	110 ACID CLEAN DUSTBLAST	<input type="checkbox"/>	CLEAN PER TS 013
900	145 INSPECTION DM & VISUAL	<input type="checkbox"/>	INSPECT PERIMS
950	40 INSPECTION NDT	<input type="checkbox"/>	***F.P.I. PER P6808 SK80195A ***SIGNIFICANT OPERATION

682

684

Legend

<input checked="" type="checkbox"/>	Completed operations
<input type="checkbox"/>	Completed rework operations
<input type="checkbox"/>	Rework operations
<input type="checkbox"/>	Operations not yet performed

Fig. 33

38/49

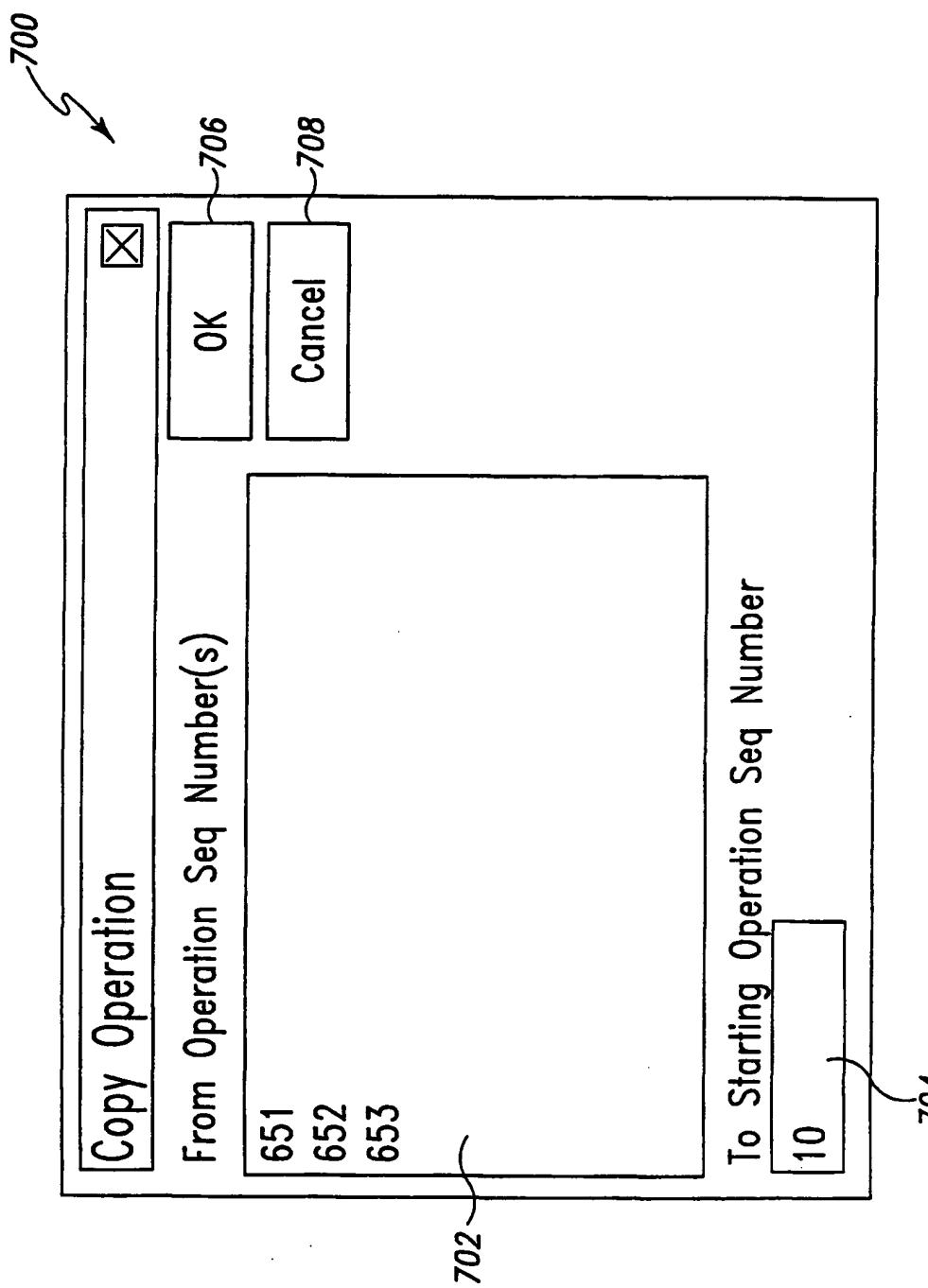


Fig. 34

39/49

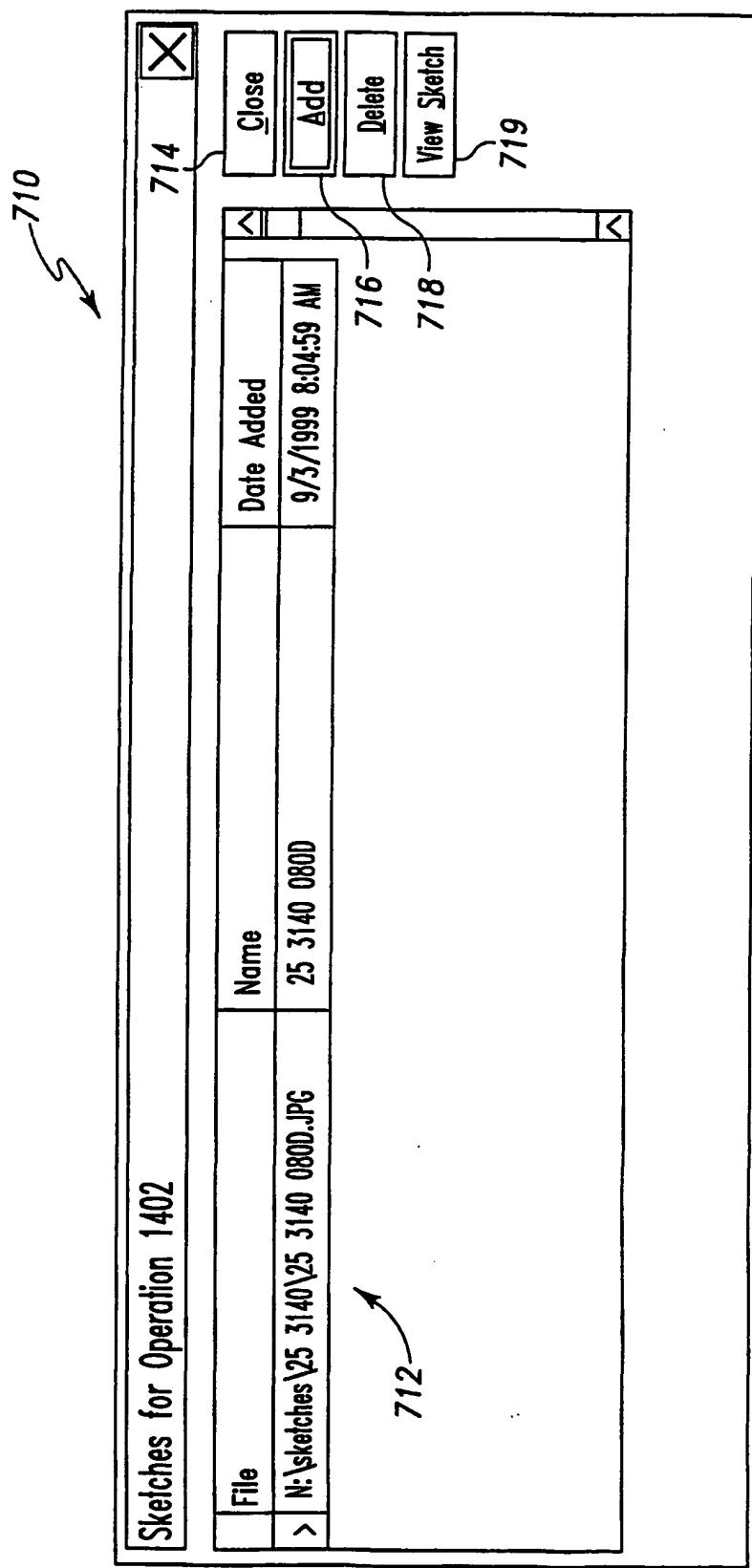
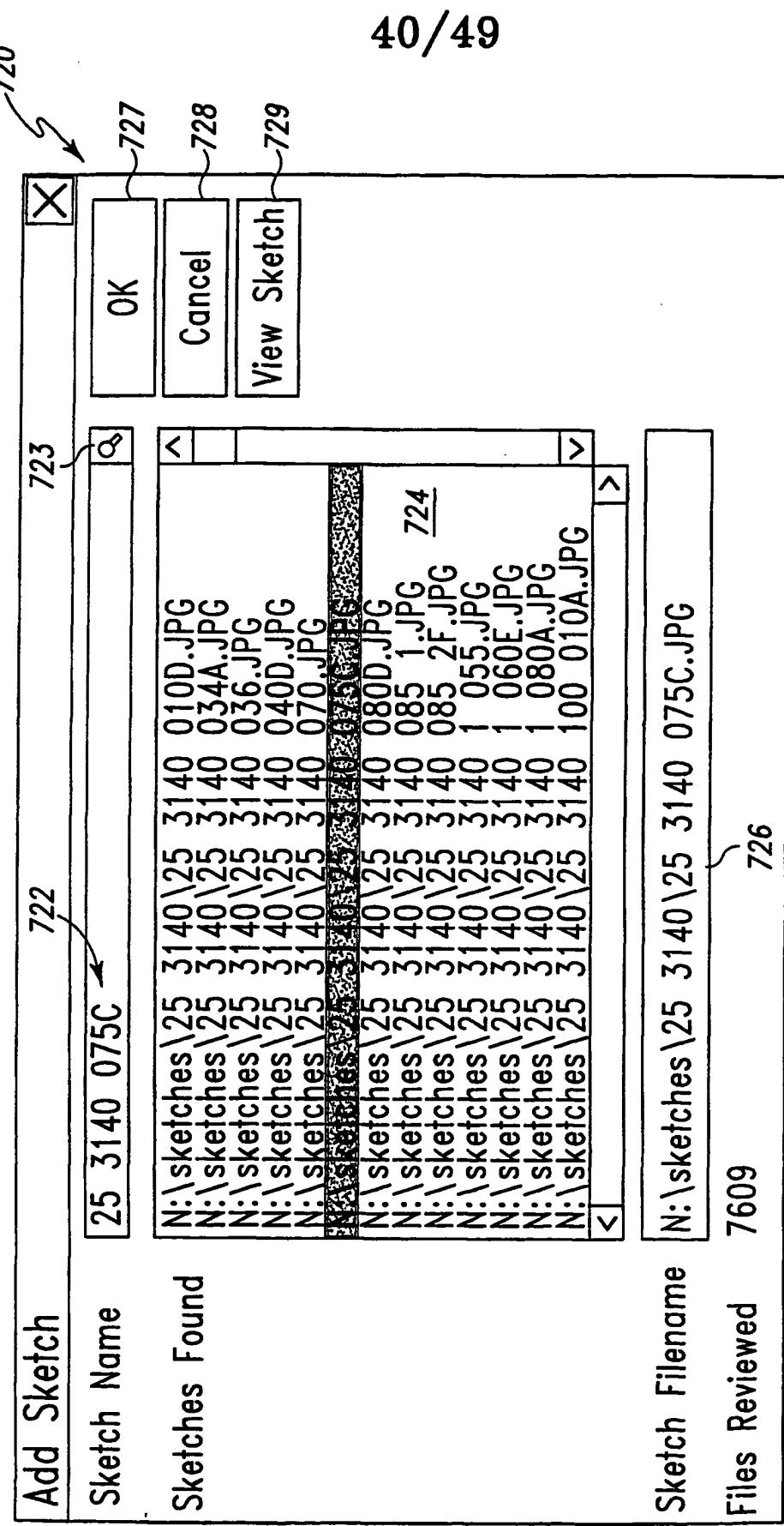


Fig. 35

**Fig. 36**

41 / 49

Add Resources to Operation 653					X
Resources Seq Num	Name	Estimated Hours	Date Added		
> <input checked="" type="checkbox"/> 730	899	2	8/26/1999 11		

Close

Add

Delete

<  >

Fig. 37

42/49

740

742

744

745

746

748

Add Resource	
Resource Name	742
Resource Seq Num	744
Estimated Time	745 (in hours)
OK	746
Cancel	748

Fig. 38

43/49

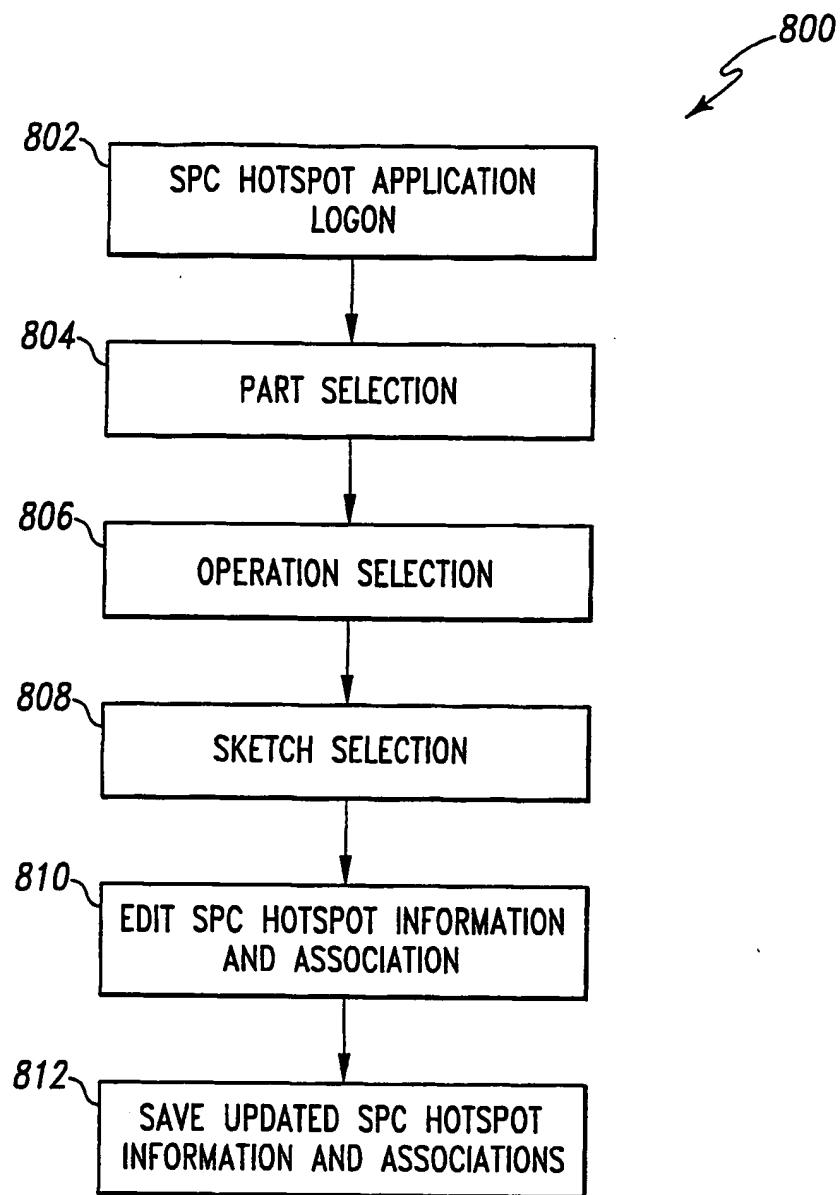


Fig. 39

44/49

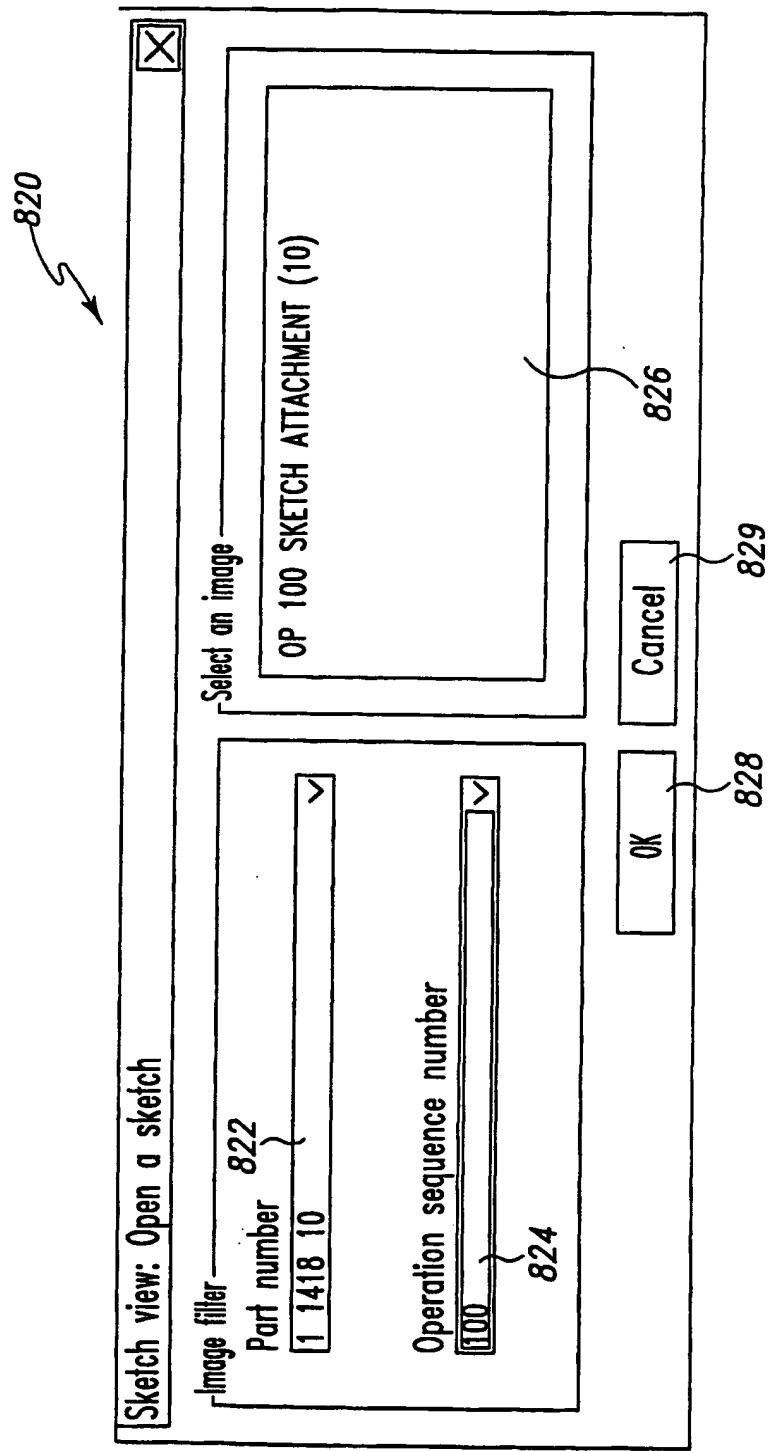


Fig. 40

45/49

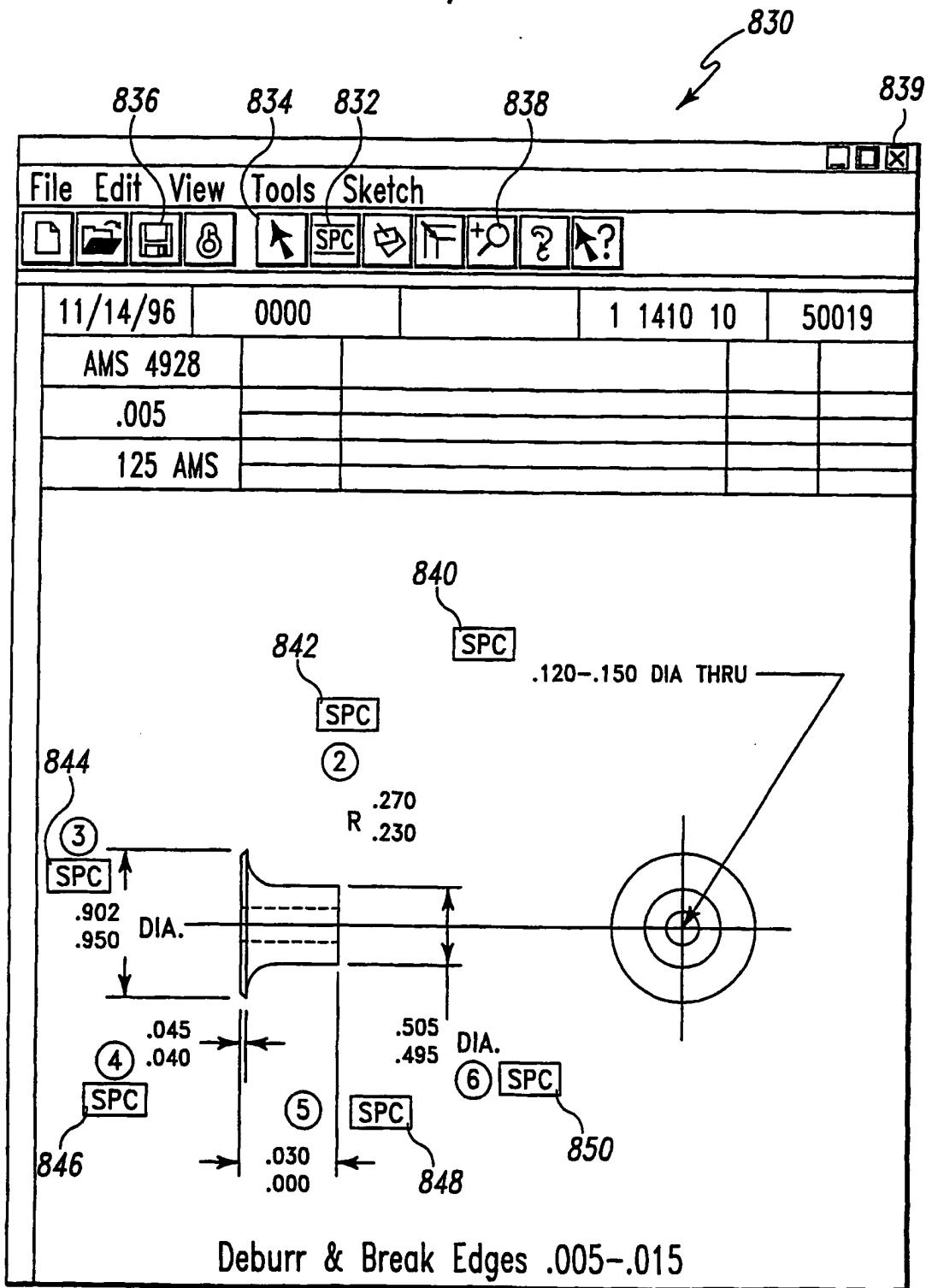


Fig. 41

831

46/49

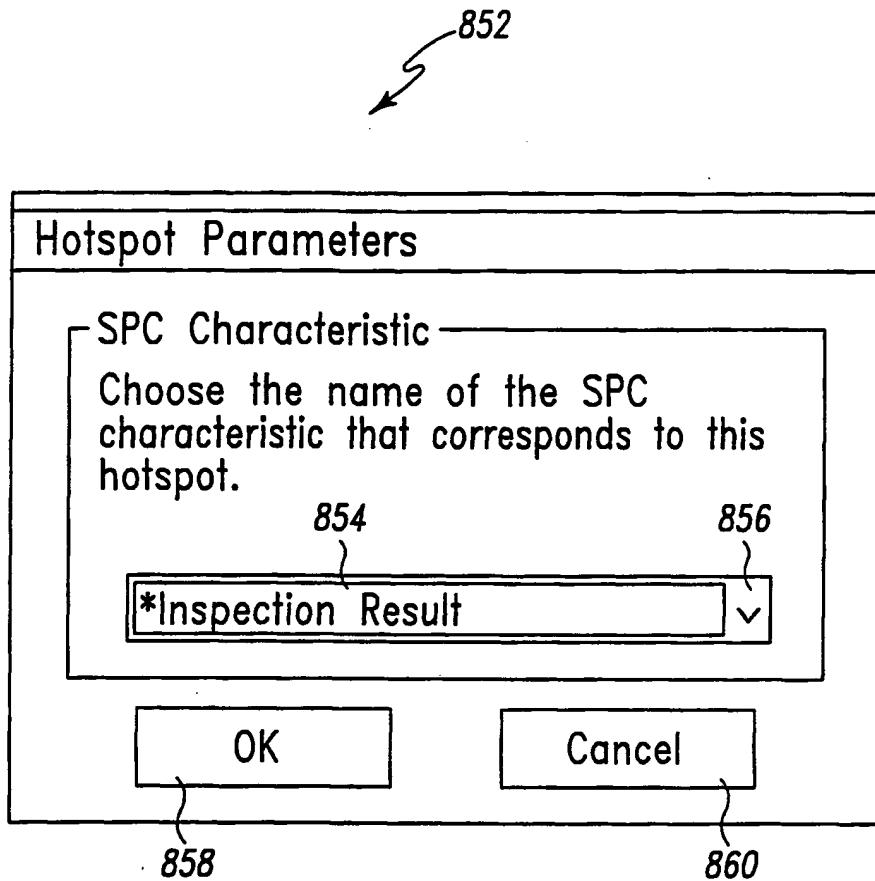


Fig. 42

47/49

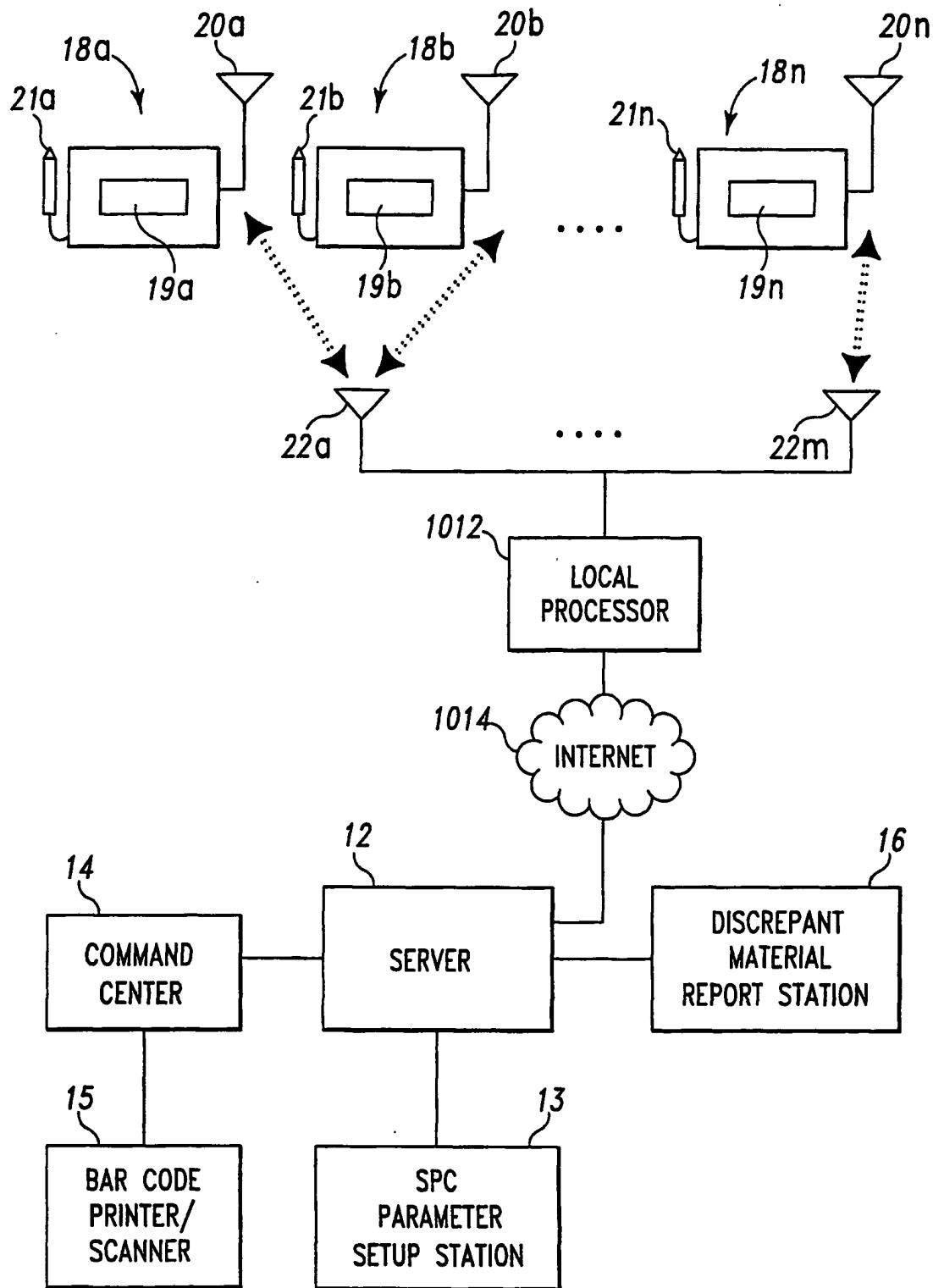


Fig. 43

48/49

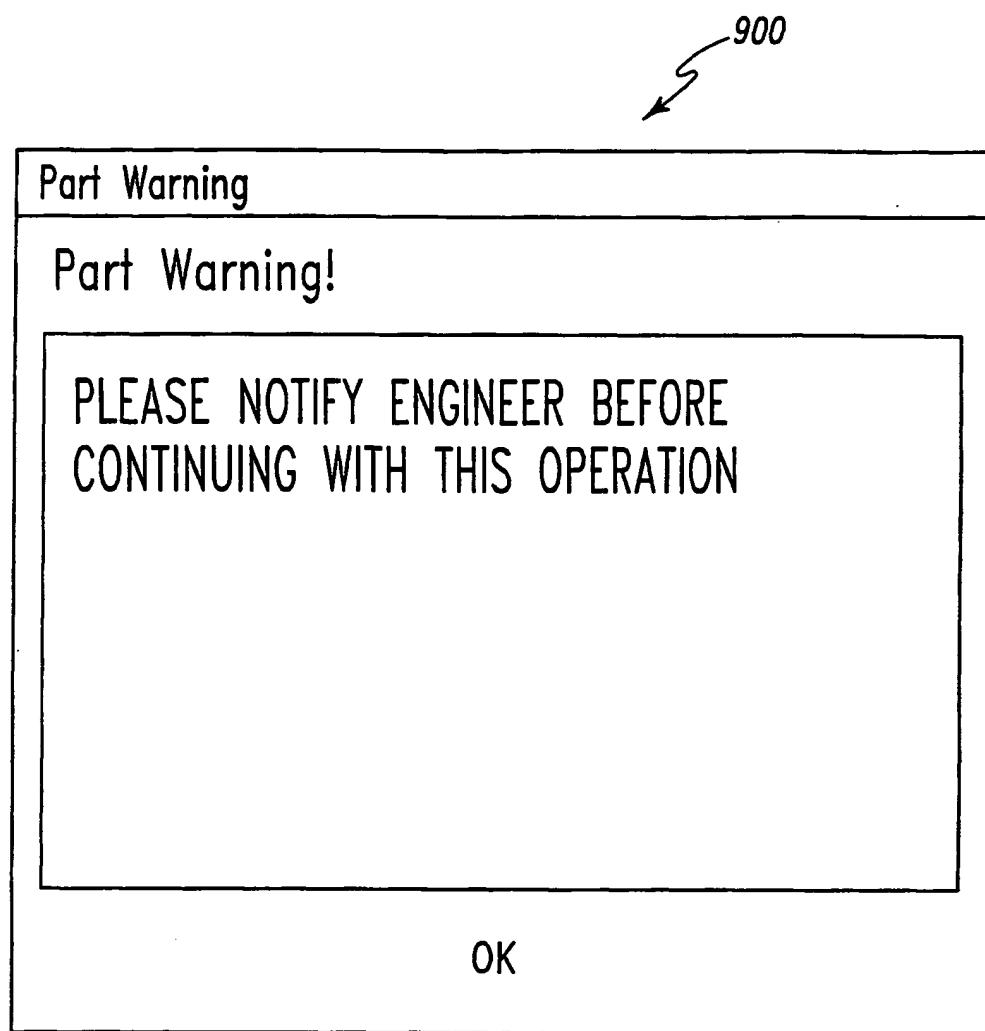


Fig. 44

49/49

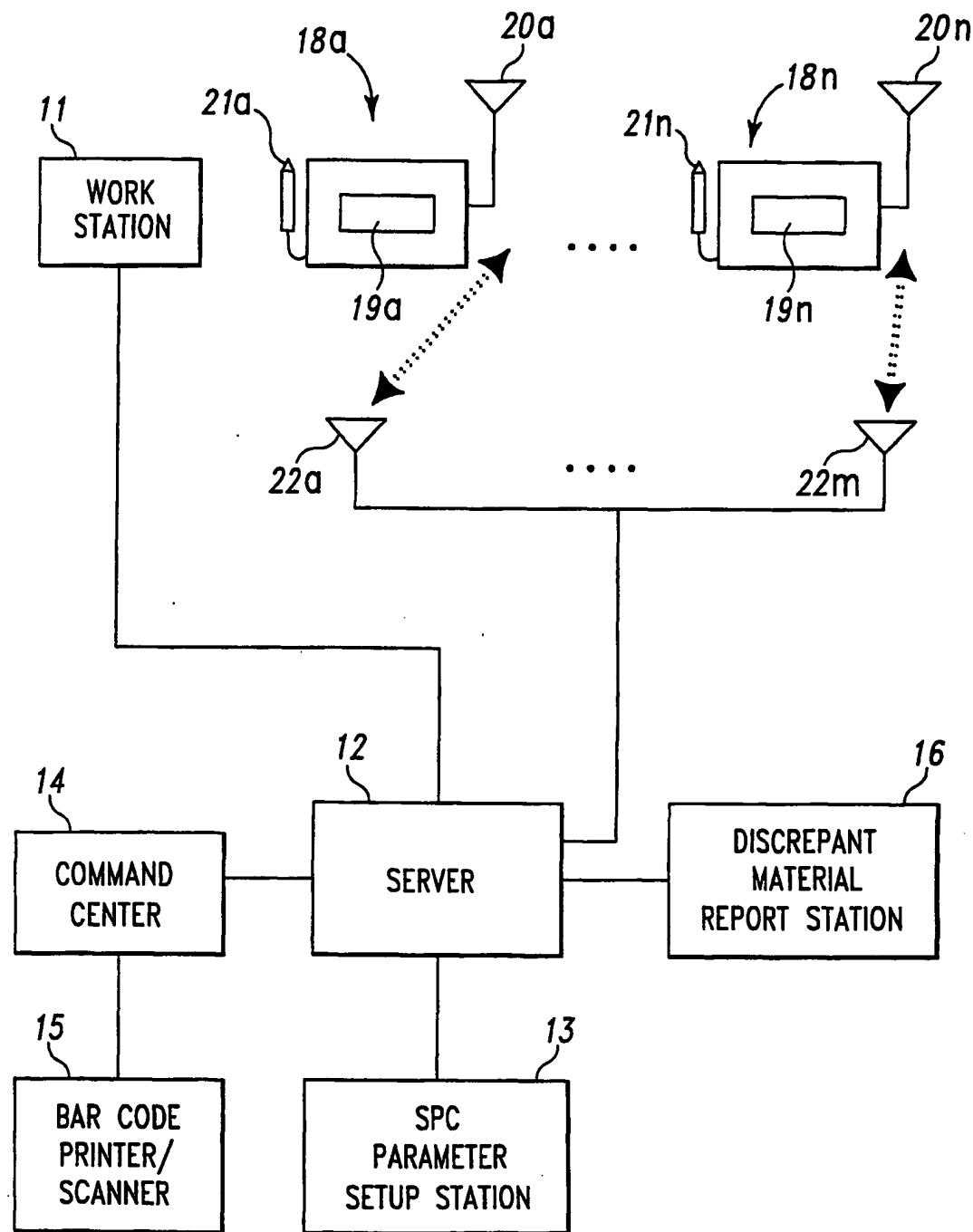


Fig. 45

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/00208

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G06F 19/00  
US CL : 700/168

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
U.S. : 700/168,11,180; 705/11; 340/825

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EAST serch terms; factory, floor, tablet, portable, terminal, wireless

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,877,961 A (MOORE) 02 March 1999 (02.03.1999), Figure 1; column 7, lines 56-67; column 8, lines 1-62	1, 2, 4-7, 22-29, 42-56
Y,P	US 6,167,464 A (KRETSCHMANN) 26 December 2000 (26.12.2000), Figures 1, 2, and 6; column 4, lines 64-67; column 5, lines 1-3 and 54-67; column 6, lines 1-34	1, 2, 4-7, 22-29, 42-56
A,P	US 6,073,058 A (COSSEN et al.) 06 June 2000 (06.06.2000) All	1-10, 22-31, 42-56
A	US 5,933,353 A (ABRIAM et al.) 03 August 1999 (03.08.1999), All	1-10, 22-31, 42-56
A	US 5,907,491 A (CANADA et al.) 25 May 1999 (25.05.1999), All	1-10, 22-31, 42-56
A	US 5,864,784 A (BRAYTON et al.) 26 January 1999 (26.01.1999), All	1-10, 22-31, 42-56
A	US 5,854,994 A (CANADA et al.) 29 December 1998 (29.12.1998), All	1-10, 22-31, 42-56
A	US 5,650,940 A (TONOZUKA et al.) 22 July 1997 (22.07.1997), All	1-10, 22-31, 42-56
A	US 5,367,624 A (COOPER) 22 November 1994 (22.11.1994), All	1-10, 22-31, 42-56
A	US 5,309,351 A (MCCAIN et al.) 03 May 1994 (03.05.1994), All	1-10, 22-31, 42-56
A	US 5,266,780 A (KAMATA et al.) 30 November 1993 (30.11.1993), All	1-10, 22-31, 42-56
A	US 5,212,635 A (FERRITER) 18 May 1993 (18.05.1993), All	1-10, 22-31, 42-56
A	US 5,068,787 A (PIPELLA et al.) 26 November 1991 (26.11.1991), All	1-10, 22-31, 42-56

Further documents are listed in the continuation of Box C.

See patent family annex.

• Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

05 April 2001 (05.04.2001)

Date of mailing of the international search report

30 APR 2001

Name and mailing address of the ISA/US

Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Facsimile No. (703)305-3230

Authorized officer

Edward (Skip) Gain

Telephone No. 703-305-7335

*James R. Matthews*

## INTERNATIONAL SEARCH REPORT

### INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/00208

#### C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim
A	US 4,380,796 A (OSTBY) 19 April 1983 (19.04.1983), All	1-10, 22-31, 42-51
A	US 5,842,181 A (FANJOY) 24 November 1998 (24.11.1998), All	1-10, 22-31, 42-51

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/00208

### Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claim Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claim Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claim Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:  
Please See Continuation Sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-10, 22-31, and 42-56

Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/00208

**BOX II. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING** This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-10, 22-31, and 42-56, drawn to a factory floor tablet system.

Group II, claim(s) 11-21, drawn to a method of monitoring jobs with portable computing devices.

Group III, claim(s) 32-41, drawn to a method for connecting multiple facilities through a network.

The inventions listed as Groups I, II, and III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of Group I is the factory floor tablet automation system utilizing a server computer for maintaining databases, the special technical feature of Group II is the method of monitoring jobs by associating portable computer devices with jobs, and the special technical feature of Group III is the method of connecting facilities through a network. As the same special technical feature is not present in all the groups, unity of invention is lacking.